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ISIS SPACE RADIATION ENVIRONMENT

REFERENCE

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FOREWORD

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This documentation is intended to serve as a guide to future mission specific specifications, in order to introduce performance requirements in coherence with incremental evolutions of the industrial satellite platforms product lines, and as to ultimately allow for standardized spacecraft operations.

The ISIS documentation was developed in compliance with the European ECSS standards and is meant to become gradually applicable to future space missions, in function of their needs and capability.

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TITLE : **ISIS Reference SPACE RADIATION ENVIRONMENT**

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SUMMARY : This document provides the radiation environment expected in a 800 km, 98° inc, 10 years generic mission, for a generic unit, which has been agreed (CNES, ASTRIUM, THALES ALENIA SPACE) the most representative mission for ISIS in terms of space radiation. Furthermore, since ISIS platform is intended to be used in an extended range of mission scenarios (LEO from 400 km to 1300 km altitude, inclination beyond 33°, and in-orbit lifetime up to 10 years), dedicated conservative LEO and GEO orbits radiation environments are also included for comparison purposes. Total dose, displacement damage, and LET/E spectrum curves are provided herein.

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1. SCOPE OF THE DOCUMENT

This document provides the radiation environment expected in a 800 km, 98° inc, ten year generic mission, for a generic unit, which has been agreed (CNES, ASTRIUM, THALES ALENIA SPACE) as the most representative mission for ISIS in terms of space radiation. This document may be considered the "PROJECT space environment specification" required by the radiation hardness assurance specification [RD01]

Furthermore, since ISIS platform is intended to be used in an extended range of mission scenarios (LEO from 400 km to 1300 km altitude, inclination beyond 33°, and in-orbit lifetime up to 10 years), dedicated conservative LEO and GEO orbits radiation environments are also included for comparison purposes. Total dose, displacement damage, and LET/E spectrum curves are provided herein.

2. DOCUMENTATION AND TERMINOLOGY

2.1. REFERENCE DOCUMENTS

Ref.	Document Name	Document Ref.	Issue	Date
RD01	"Radiation Hardness Assurance for ISIS"	CNES/DCT/AQ/EC 2009.10799	1.1	October, 2009
RD02	"ISIS General Requirements for Satellite Product Lines"	ISIS-SL-TS-135-CNES	4	30/09/2011
RD03	"CERES. Modélisation de l'environnement Radiatif"	CNES/DCT/AQ/EC 2010.22736	1	2010

2.2. APPLICABLE DOCUMENTS

Ref.	Document Name	Document Ref.	Issue	Date
AD01	Space Environment	ECSS-E-ST-10-04	C	November, 2008

2.3. TERMINOLOGY & ABBREVIATIONS

Abbrev.	Meaning	Abbrev.	Meaning
DDD	Displacement Damage Dose	TID	Total Ionizing Dose
ESP	Energetic Solar Protons	LEO	Low Earth Orbit
GCR	Galactic Cosmic Rays	SAA	South Atlantic Anomaly
LET	Linear Energy Transfer	SEE	Single Event Effect

3. INTRODUCTION

The goal of this document is to define the radiation environment (TID, DDD and LET spectrum) for a generic mission of the ISIS platform (800 km, 98° inc, 10 years duration). The generic mission from the radiation point of view has been agreed by the ISIS Radiation Working Group (TAS + AST + CNES). Given that the ISIS platform could be used in other orbit types [RD02], some other representative types have been chosen for comparison purposes and PROJECT considerations, see Table 1.

Orbit Type	Altitude (circular orbit)	Inclination	Duration
LEO (Reference Orbit)	800 km	98°	10 years
GEO	35870 km	0 °	18 years (15 years + 20% margin)
Lowest LEO	400 km	33°	10 years
JASON 2	1330 km	66°	10 years
SWOT	970 km	78°	5 years
CERES	Confidential	Confidential	Confidential

Table 1. Orbits taken into account to perform the radiation environment calculation.

The 800 km altitude orbit has been chosen because it represents a good compromise as most of the LEO earth observation satellites are flying in similar or lower orbits. Remember that LEO orbits are rich in protons due to the crossings through the SAA and that proton flux steadily increases with altitude up to around 2500 km of altitude where the maximum flux of the inner Van Allen belt is found.

SWOT and CERES have been added because they are the two first candidate missions for ISIS but full / detailed calculation results are not provided in this document because each mission must have a dedicated space radiation environment specification document. This document is not intended to supersede the dedicated radiation environment specification of any mission that uses ISIS platform.

4. MODELS APPLIED AND CALCULATIONS PERFORMED

All calculations have been performed as required in § 9 of [AD1].

4.1. ENVIRONMENT MODELS

These considerations lead to the following calculus hypotheses:

- Calculus conditions for the outer electron belt: Solar_MAX (AE8MAX model) but for GEO orbit where IGE2006 has been used.
- Calculus conditions for the inner proton belt: Solar_MIN (AP8MIN model).
- Model to calculate the proton average fluxes from a solar flare: ESP (85%) with all the mission lifetime being in active period when the mission duration is equal to or less than 7 years, 7 years of active period otherwise. In the case of a 18 years GEO mission, the active period used is 12.5 years.

- The magnetic field configuration used is the NASA and ECSS standard (JENSEN-CAIN 1960 for AP8MIN and AE8MAX).
- The geomagnetic cut-off has been considered in *calm conditions* and with *earth shadowing*.
- The average fluxes have been obtained using 400 orbits with 200 points each one for all orbit types.
- The flux of cosmic rays has been calculated using the CREME96 model in solar minimum conditions (worst case) behind an equivalent shielding of 3.7 mm of aluminium.
- The flux of solar heavy ions has been calculated using CREME96 worst week model.

4.2. TARGET MATERIALS

The ionizing doses and the LET spectra have been calculated for silicon targets. The non-ionizing (displacement damage) doses have been calculated for both silicon and gallium arsenide.

4.3. IONIZING DOSE CURVE

The ionizing dose has been calculated at the centre of a solid sphere of aluminium.

4.4. NON-IONIZING DOSE CURVE (DISPLACEMENT DAMAGE DOSE)

The displacement damage doses are given in terms of equivalent 50 MeV proton fluence leading to the same degradation at the end of mission's lifetime. The value 50 MeV is normally used during the proton irradiation tests of electronic parts. The calculations have been performed for Si and GaAs as target materials.

5. RESULTS

5.1. TOTAL IONISING DOSE (TID)

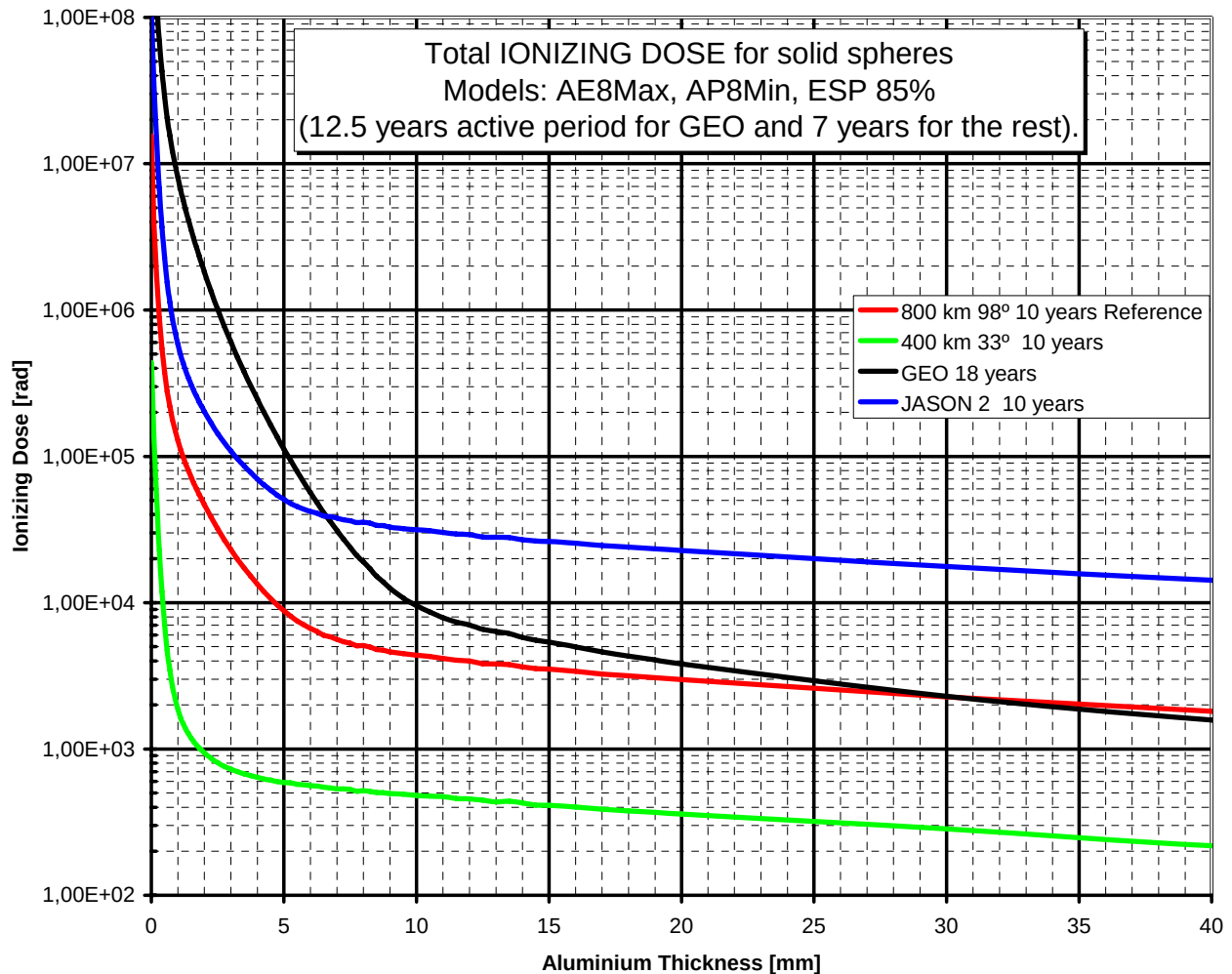


Figure 1. Worst case ionizing dose at the centre of aluminium solid spheres. The numerical values corresponding to the points of these curves are given in Table 2 (see Appendix).

In the reference orbit, the total ionizing dose is dominated by the contribution of the trapped protons for a shielding thickness greater than 4 mm aluminium meanwhile the curve is dominated by trapped electrons for a shielding thinner than 2 mm aluminium. The received dose rises if shielding diminishes, especially for values smaller than 6 mm where the slope of the curve is significant. The effect of solar protons and braking radiation (bremsstrahlung) is marginal. If we compare with the rest of orbits, the reference mission will receive a dose much higher than the 400 km 33° for the same shielding. At the same time, reference orbit will receive a dose much lower than the one of JASON 2 for the same shielding. In the case of GEO, the received amount of dose is the same order of magnitude to that of the reference orbit when a thick (> 10 mm Al) shielding is applied.

5.2. DISPLACEMENT DAMAGE DOSE (DDD) ON SILICON

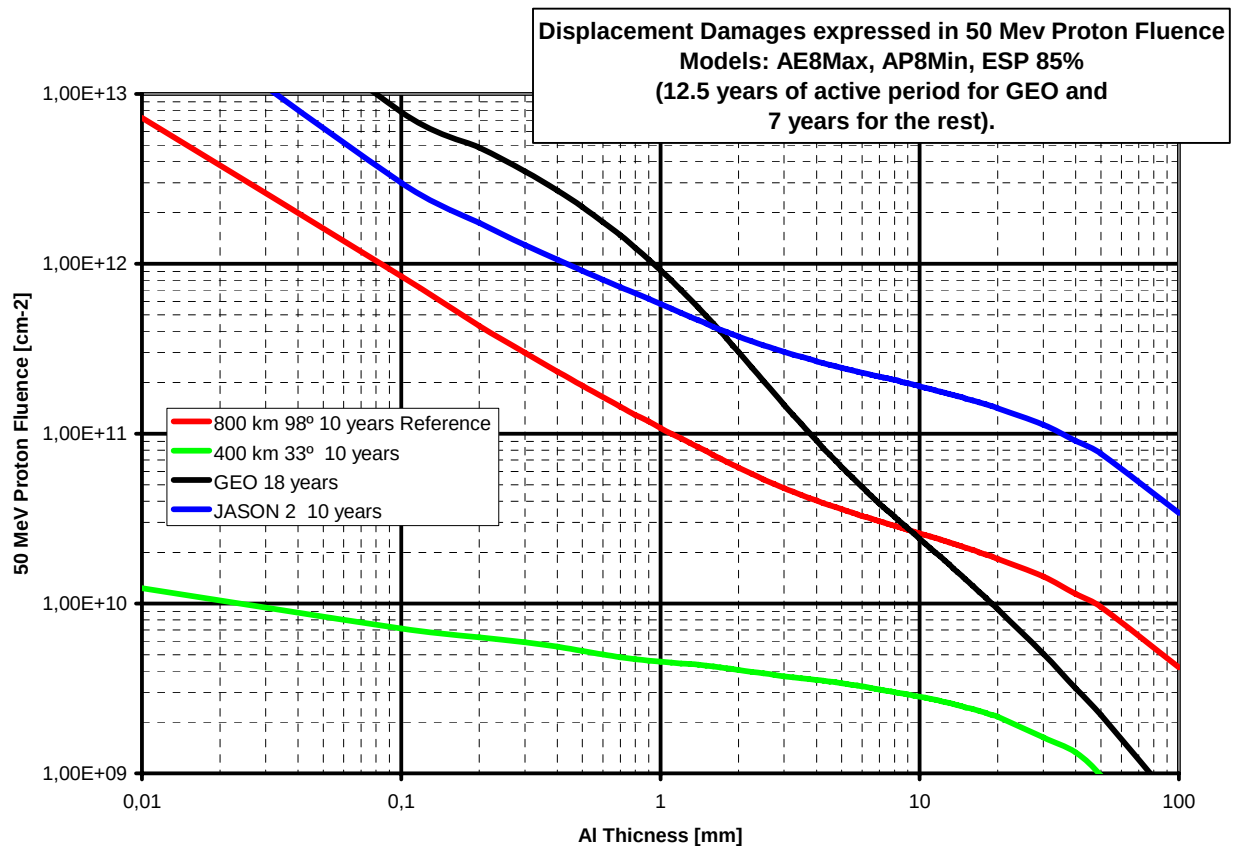


Figure 2. Worst case displacement damage dose expressed in terms of equivalent 50 MeV proton fluence for silicon target material. The numerical values corresponding to the points of these curves are given in Table 3 (see Appendix).

Figure 2 presents the DDD on silicon target materials versus shielding thickness for the reference orbit and for other missions for comparison purposes. One can see again that the displacement damage dose depends a lot on the chosen orbit. Notice that again the received dose (DDD) can be lower in GEO than in the reference orbit (800 km, 98° inc, ten years) if an important shielding level is applied, for instance 15 mm Al. In any case, a mission type JASON 2 is far above the other cases studied even for high shielding levels.

Optoelectronics are very sensitive to DDD, care should be taken when using these devices, particularly in proton-rich orbits such as JASON 2 as shielding is not very effective against protons.

5.3. DISPLACEMENT DAMAGE DOSE (DDD) IN GALLIUM ARSENIDE

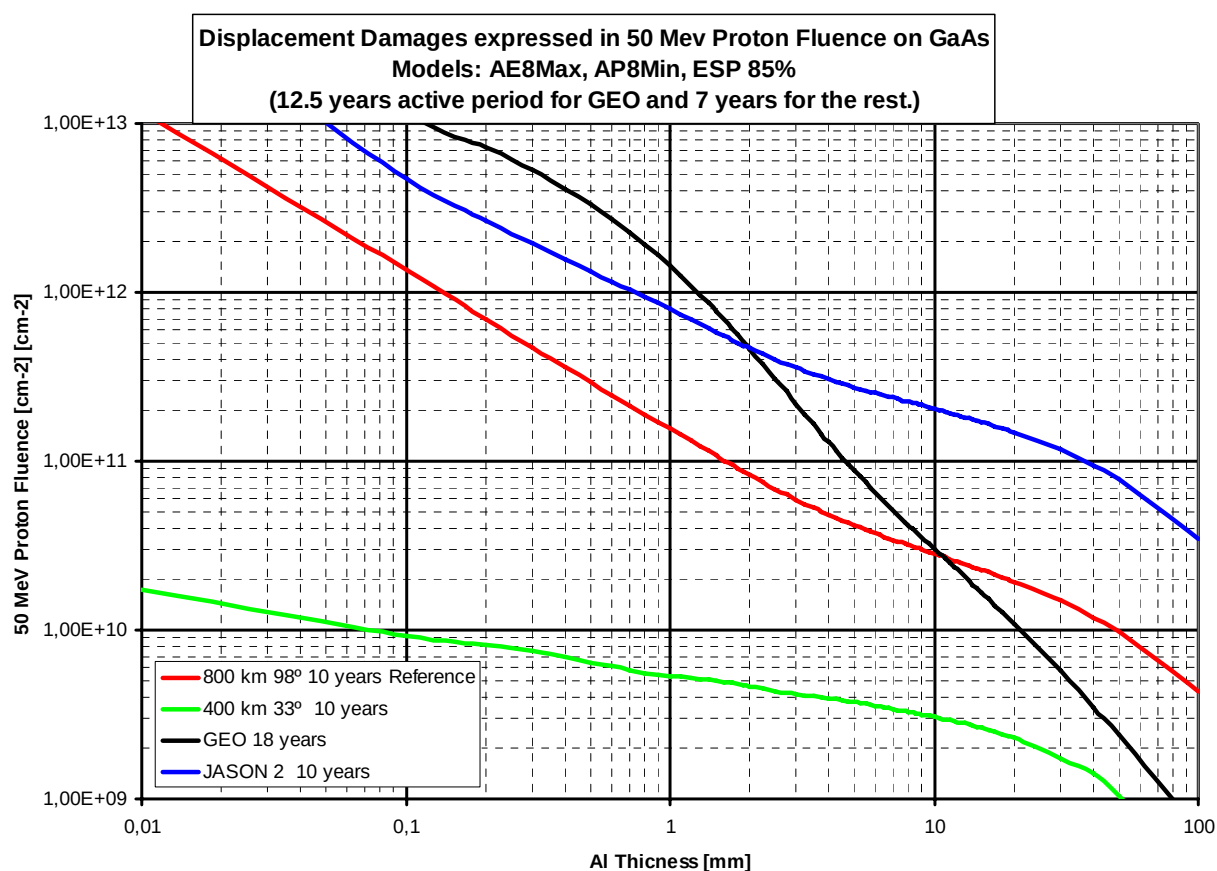


Figure 3. Worst case displacement damage dose in GaAs expressed in terms of equivalent 50 MeV proton fluence. The numerical values corresponding to the points of these curves are given in Table 4 (see Appendix).

The DDD on GaAs has also been included in this document to several potentially sensitive devices like optical emitter – receiver based on GaAs LED diodes and high frequency transistors. DDD shows in this figure a very similar behaviour to that of silicon materials.

5.4. LINEAR ENERGY TRANSFER (LET)

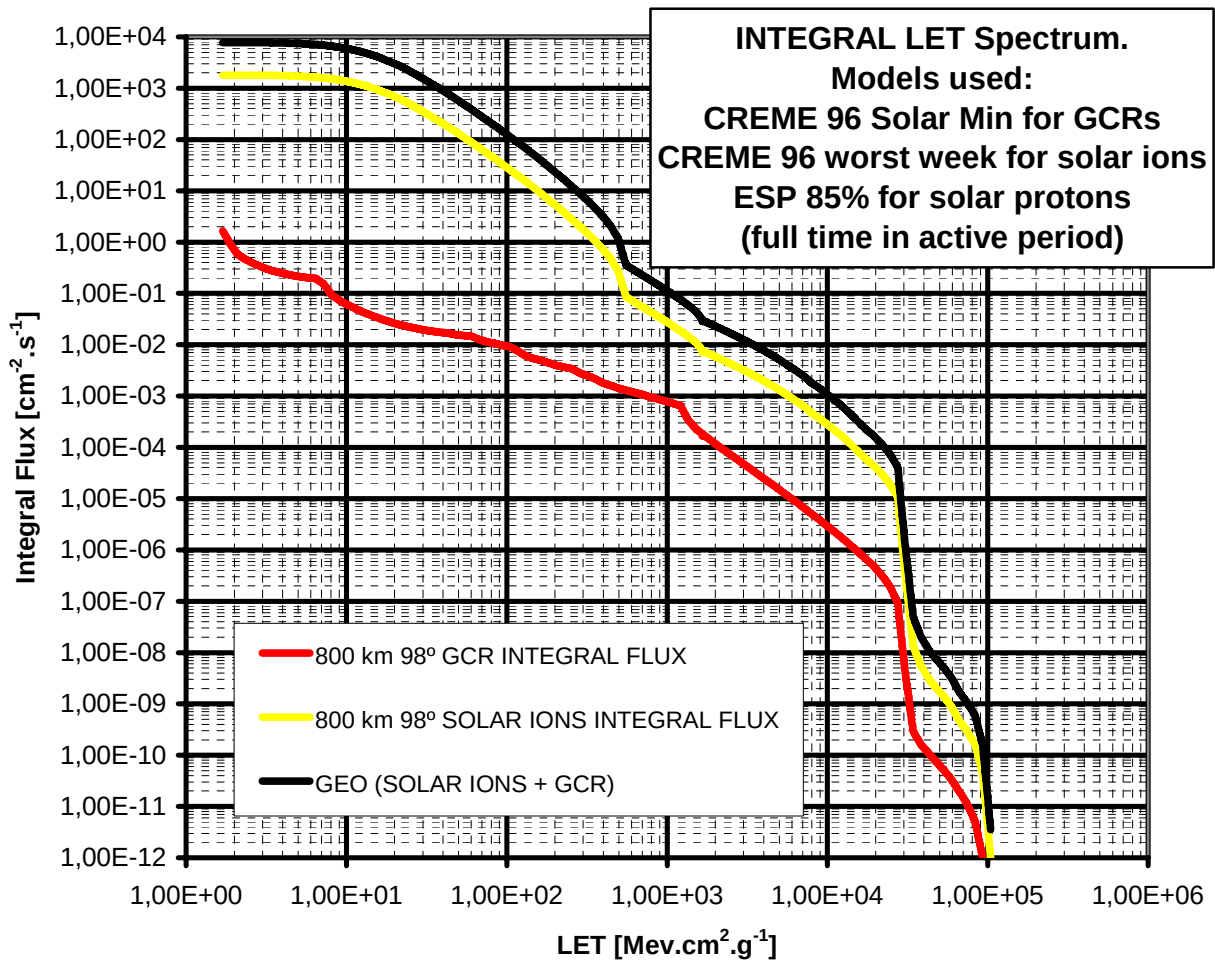


Figure 4. GCR and solar worst case integral LET spectrum. This spectrum has been calculated using an equivalent shielding of 3.7 mm Al. This graph is normally used as input for single event effects calculations. Numerical values are given in Table 5 (see Appendix).

GCR and Solar Flare LET spectrum contribution have been calculated to help in SEE rate calculations either in worst case or normal conditions. The value of 3.7 mm of shielding is normally used as reference for SEE calculations when real shielding is still unknown. In fact, GCRs are rare but very energetic particles so they are very hard to stop even adding extra local shielding. LET calculations for GEO orbit have been included for comparison, GEO orbit is more exposed to SEE than LEO orbits because the latter are less protected by the Earth's magnetic field. .

5.5. TRAPPED PROTONS SPECTRA

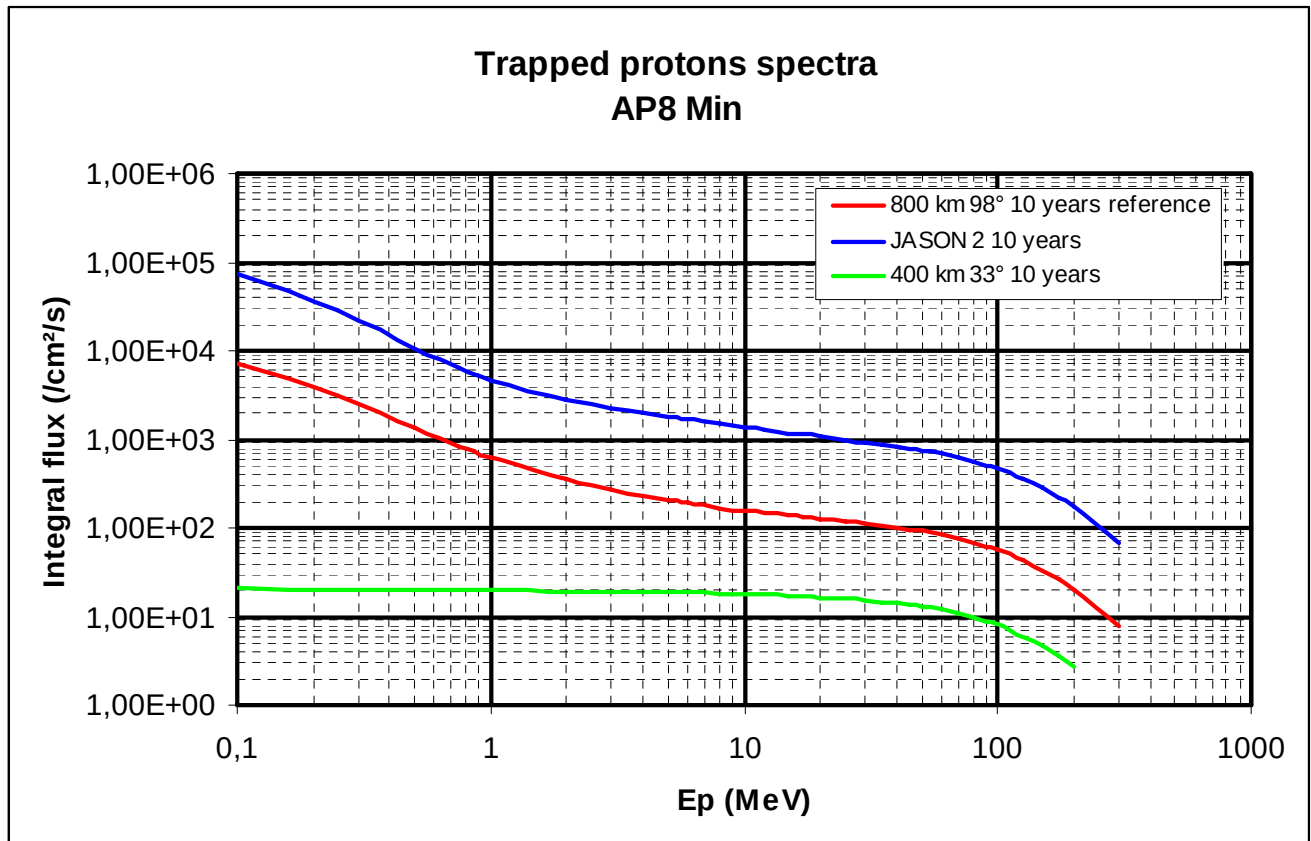


Figure 5. Trapped proton integral spectra for ISIS reference LEO, JASON 2, and Lowest LEO orbits. This graph is normally used as input for cumulative effects (TID and TNID) and single event effects calculations for devices with LET threshold lower than 15 MeV.cm²/mg. Numerical values are given in Table 6 (see Appendix).

5.6. SOLAR FLARE PROTONS SPECTRA

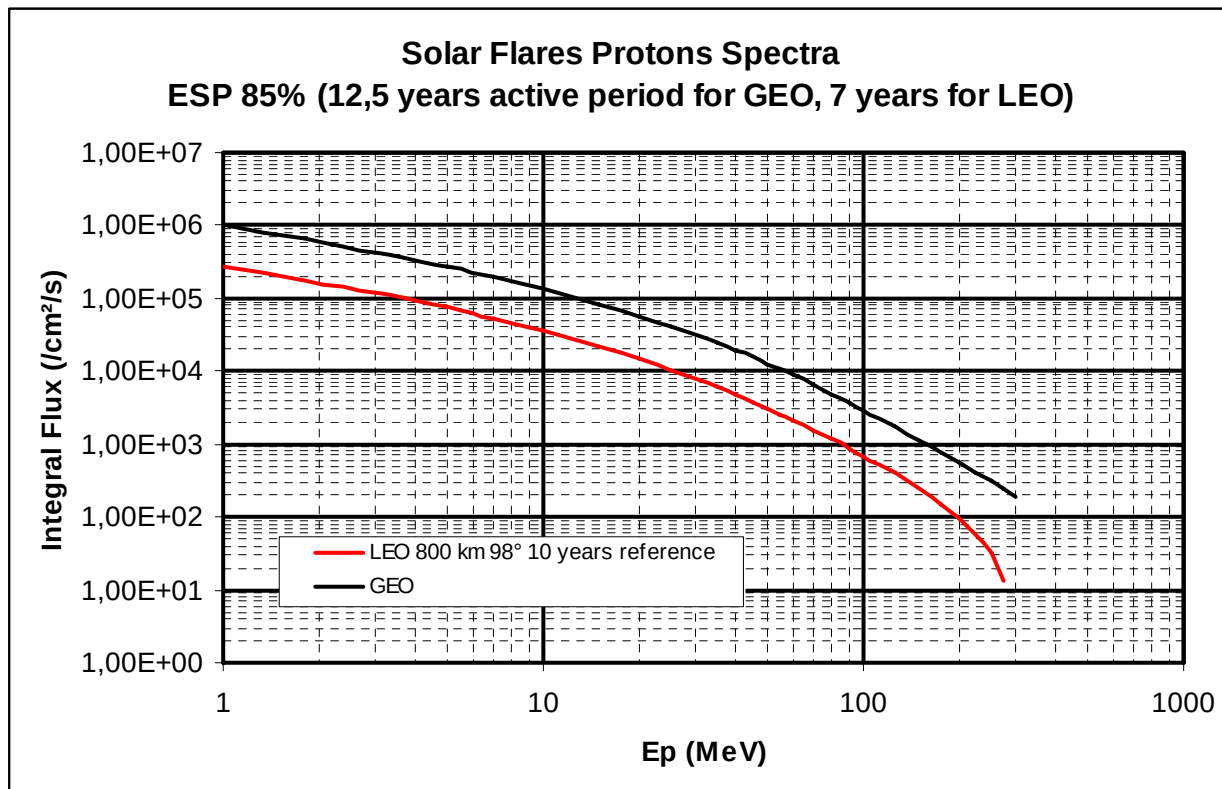


Figure 6. Solar Flares proton integral spectra for ISIS reference LEO and GEO orbits. This graph is normally used as input for cumulative effects (TID and TNID) and single event effects calculations for devices with LET threshold lower than 15 MeV.cm²/mg. Numerical values are given in Table 7 *Erreur ! Source du renvoi introuvable.* (see Appendix).

6. CONCLUSION

The results presented in this document (with the help of [RD01]) allow to choose the adequate electronic components to deal with the radiation constraints of the ISIS reference mission (800 km, 98° inc, 10 years). The choice of the reference mission has been agreed by the ISIS radiation working group (TAS, AST, CNES). Given that ISIS will be used mainly in LEO missions, the reference mission will cover most of the cases from the environment radiation point of view. However, a platform designed for a 800 km of altitude, 98° of inclination and 10 years lifetime will badly resist the same period of time in a JASON 2 orbit.

It is obvious that the received dose can change a lot depending on the orbit and it makes it very difficult to use the same components for all the cases as such thing will increase the cost (all the satellites designed with a high dose constraint) or the failure risk (all the satellites designed with a low dose constraint) for the platform.

Although component selection shall be made on the base of case by case (taking into account each electronic part and its corresponding shielding), it has been agreed to define a reference minimum total ionising dose level. The ISIS radiation working group has agreed to not apply a top level dose requirement for all the missions but to recommend the following instead: **All the spacecraft electronic components should be able to withstand a received ionising dose equal or superior to that received in the reference orbit (800 km 98° 10 years) with an equivalent shielding of 15 mm Al which is 3.5 krad.** The shielding level of 15 mm Al has been chosen because that is an amount of local shielding that could be in practice added to protect a given component. In other words, assuming the reference mission, a component resisting only 3.5 krad could be used only if it is protected by 15 mm Al of equivalent shielding. The electronics not resisting at least 3.5 krad are not recommended as they would require an excessive amount of shielding and possibly additional radiation justification, in agreement with [RD01].

These reference values are only valid if the assumptions are valid, in case of higher LEO orbit or lower shielding, radiation may degrade the electronic part's performance in significant way before the nominal end of mission.

The SWOT (970 km altitude 78° inclination 5 years) and CERES (confidential orbit parameters) missions are the first candidates to use the ISIS platform. We can now assess if the reference orbit covers these missions from a radiation point of view:

- The CERES mission will be exposed in general terms to a less constraining space environment [RD3] than that of the reference orbit. CERES will receive 2 krad in terms of total ionising dose behind a 15 mm Al, just to cite one parameter. Thus, CERES is covered by the reference orbit from the space radiation point of view.
- The SWOT orbit is exposed to a more harsh space radiation environment. For instance, the expected received dose behind 15 mm Al is around 3.5 krad, notice that this value is similar to that of the reference orbit but SWOT expected lifetime is 5 years while the reference orbit considers 10 years of lifetime. Moreover, the expected silicon DDD expressed in 50 MeV proton flux for SWOT is $2.15 \times 10^{10} \text{ p}^+/\text{cm}^2$ while it is $2.13 \times 10^{10} \text{ p}^+/\text{cm}^2$ for the reference orbit. Finally, the SWOT's GCR LET spectrum curve behind 3.7 mm Al is again similar to that of the reference orbit. In other words, thanks to its relatively reduced lifetime, SWOT is generally covered by the reference orbit from the space radiation point of view. All the radiation environment calculations concerning SWOT used in this paragraph have been made according section 4 of this document (Models Applied and Calculation Performed).

7. APPENDIX

Table 227. Worst case ionizing dose at the centre of aluminium solid spheres (silicon target).

TID. Target material silicon				
Thickness [mm_Al]	Total Dose [rad]			
	800 km 98° inc 10 years Reference	400 km 33° inc 10 years	GEO 18 years	JASON 2 10 years
1,0000E-02	1,5530E+07	4,3800E+05	6,6810E+09	1,0630E+08
1,0000E-01	3,9650E+06	1,3790E+05	3,4430E+08	3,5660E+07
2,0000E-01	1,6820E+06	5,1650E+04	1,2970E+08	1,4460E+07
3,0000E-01	8,8700E+05	2,2870E+04	6,9610E+07	6,8010E+06
4,0000E-01	5,4610E+05	1,1900E+04	4,2910E+07	3,6950E+06
5,0000E-01	3,7540E+05	7,1140E+03	2,8740E+07	2,2760E+06
6,0000E-01	2,7850E+05	4,7430E+03	2,0570E+07	1,5440E+06
7,0000E-01	2,1840E+05	3,4450E+03	1,5520E+07	1,1280E+06
8,0000E-01	1,7790E+05	2,6740E+03	1,2160E+07	8,7160E+05
9,0000E-01	1,4940E+05	2,1910E+03	9,7930E+06	7,0300E+05
1,0000E+00	1,2810E+05	1,8690E+03	8,0410E+06	5,8470E+05
1,1000E+00	1,1200E+05	1,6470E+03	6,7020E+06	4,9990E+05
1,2000E+00	9,8880E+04	1,4860E+03	5,6490E+06	4,3450E+05
1,3000E+00	8,8390E+04	1,3660E+03	4,8070E+06	3,8400E+05
1,4000E+00	7,9580E+04	1,2680E+03	4,1210E+06	3,4310E+05
1,5000E+00	7,2130E+04	1,1890E+03	3,5550E+06	3,0960E+05
1,6000E+00	6,5740E+04	1,1250E+03	3,0840E+06	2,8180E+05
1,7000E+00	6,0000E+04	1,0670E+03	2,6880E+06	2,5720E+05
1,8000E+00	5,5100E+04	1,0190E+03	2,3530E+06	2,3670E+05
1,9000E+00	5,0710E+04	9,7780E+02	2,0660E+06	2,1860E+05
2,0000E+00	4,6720E+04	9,3950E+02	1,8210E+06	2,0240E+05
2,2500E+00	3,8460E+04	8,6360E+02	1,3460E+06	1,6920E+05
2,5000E+00	3,2040E+04	8,0630E+02	1,0140E+06	1,4390E+05
2,7500E+00	2,6980E+04	7,6160E+02	7,7740E+05	1,2410E+05
3,0000E+00	2,3080E+04	7,2920E+02	6,0500E+05	1,0900E+05
3,2500E+00	1,9830E+04	7,0100E+02	4,7610E+05	9,6190E+04
3,5000E+00	1,7250E+04	6,7500E+02	3,7860E+05	8,5950E+04
3,7500E+00	1,5150E+04	6,5770E+02	3,0400E+05	7,7510E+04
4,0000E+00	1,3330E+04	6,4000E+02	2,4580E+05	6,9940E+04
4,2500E+00	1,1850E+04	6,2260E+02	2,0010E+05	6,3740E+04
4,5000E+00	1,0670E+04	6,1400E+02	1,6420E+05	5,8760E+04
4,7500E+00	9,6100E+03	5,9840E+02	1,3540E+05	5,4220E+04
5,0000E+00	8,8220E+03	5,9110E+02	1,1250E+05	5,0930E+04
5,2500E+00	8,0890E+03	5,8740E+02	9,3820E+04	4,7800E+04
5,5000E+00	7,5060E+03	5,7380E+02	7,8720E+04	4,5360E+04
5,7500E+00	7,0480E+03	5,6980E+02	6,6510E+04	4,3510E+04
6,0000E+00	6,6620E+03	5,6210E+02	5,6510E+04	4,1960E+04
6,2500E+00	6,3640E+03	5,5810E+02	4,8360E+04	4,0830E+04
6,5000E+00	5,9790E+03	5,4810E+02	4,1270E+04	3,9110E+04
6,7500E+00	5,8350E+03	5,4060E+02	3,5900E+04	3,8690E+04

TID. Target material silicon				
Thickness [mm_Al]	Total Dose [rad]			
	800 km 98° inc 10 years Reference	400 km 33° inc 10 years	GEO 18 years	JASON 2 10 years
7,0000E+00	5,6160E+03	5,3460E+02	3,1170E+04	3,7760E+04
7,2500E+00	5,4060E+03	5,3360E+02	2,7150E+04	3,6810E+04
7,5000E+00	5,2880E+03	5,2890E+02	2,3920E+04	3,6350E+04
7,7500E+00	5,0720E+03	5,1500E+02	2,0950E+04	3,5230E+04
8,0000E+00	5,0920E+03	5,1760E+02	1,8990E+04	3,5530E+04
8,2500E+00	4,9730E+03	5,1250E+02	1,7000E+04	3,4930E+04
8,5000E+00	4,7720E+03	5,0420E+02	1,5120E+04	3,3760E+04
8,7500E+00	4,7320E+03	5,0240E+02	1,3850E+04	3,3600E+04
9,0000E+00	4,6050E+03	4,9640E+02	1,2570E+04	3,2850E+04
9,5000E+00	4,4740E+03	4,9120E+02	1,0770E+04	3,2090E+04
1,0000E+01	4,3790E+03	4,8150E+02	9,5270E+03	3,1540E+04
1,0500E+01	4,2880E+03	4,7560E+02	8,6400E+03	3,0990E+04
1,1000E+01	4,1580E+03	4,7370E+02	7,9010E+03	3,0180E+04
1,1500E+01	4,0470E+03	4,5920E+02	7,3630E+03	2,9490E+04
1,2000E+01	3,9890E+03	4,5640E+02	7,0270E+03	2,9150E+04
1,2500E+01	3,8260E+03	4,4610E+02	6,5670E+03	2,8120E+04
1,3000E+01	3,8040E+03	4,3480E+02	6,3610E+03	2,8010E+04
1,3500E+01	3,7670E+03	4,3920E+02	6,1430E+03	2,7810E+04
1,4000E+01	3,6280E+03	4,2750E+02	5,7880E+03	2,6920E+04
1,4500E+01	3,5400E+03	4,1380E+02	5,5290E+03	2,6360E+04
1,5000E+01	3,5140E+03	4,1200E+02	5,3700E+03	2,6220E+04
1,6000E+01	3,4000E+03	4,0030E+02	4,9870E+03	2,5510E+04
1,7000E+01	3,2540E+03	3,8760E+02	4,6040E+03	2,4560E+04
1,8000E+01	3,1640E+03	3,7790E+02	4,3190E+03	2,3980E+04
1,9000E+01	3,0730E+03	3,6890E+02	4,0550E+03	2,3370E+04
2,0000E+01	2,9790E+03	3,5880E+02	3,8090E+03	2,2740E+04
3,0000E+01	2,2690E+03	2,8440E+02	2,2930E+03	1,7670E+04
4,0000E+01	1,8110E+03	2,1770E+02	1,5730E+03	1,4250E+04
5,0000E+01	1,5180E+03	1,9300E+02	1,1980E+03	1,2060E+04
1,0000E+02	5,9720E+02	2,8960E+01	3,3050E+02	4,8330E+03

Table 338. Worst case displacement damage dose in Si expressed in terms of equivalent 50 MeV proton fluence.

Al Thickness [mm]	Displacement Damages expressed in Equivalent 50 Mev Protons Fluence [cm ⁻²]			
	800 km 98° 10 years Reference	400 km 33° 10 years	GEO 18 years	JASON 2 10 years
1,00E-02	7,24E+12	1,23E+10	1,13E+14	3,71E+13
1,00E-01	8,46E+11	7,12E+09	7,83E+12	3,00E+12
2,00E-01	4,32E+11	6,33E+09	4,84E+12	1,74E+12
3,00E-01	2,99E+11	5,91E+09	3,50E+12	1,29E+12
4,00E-01	2,32E+11	5,58E+09	2,70E+12	1,06E+12
5,00E-01	1,92E+11	5,26E+09	2,16E+12	9,09E+11
6,00E-01	1,64E+11	5,01E+09	1,76E+12	8,04E+11
7,00E-01	1,44E+11	4,83E+09	1,47E+12	7,29E+11
8,00E-01	1,29E+11	4,70E+09	1,24E+12	6,71E+11
9,00E-01	1,18E+11	4,61E+09	1,06E+12	6,22E+11
1,00E+00	1,08E+11	4,55E+09	9,17E+11	5,81E+11
1,10E+00	1,00E+11	4,49E+09	7,99E+11	5,45E+11
1,20E+00	9,38E+10	4,44E+09	7,01E+11	5,14E+11
1,30E+00	8,81E+10	4,40E+09	6,19E+11	4,88E+11
1,40E+00	8,33E+10	4,36E+09	5,52E+11	4,65E+11
1,50E+00	7,91E+10	4,31E+09	4,94E+11	4,45E+11
1,60E+00	7,46E+10	4,26E+09	4,44E+11	4,25E+11
1,70E+00	7,13E+10	4,21E+09	4,00E+11	4,10E+11
1,80E+00	6,83E+10	4,16E+09	3,63E+11	3,96E+11
1,90E+00	6,56E+10	4,11E+09	3,30E+11	3,84E+11
2,00E+00	6,31E+10	4,06E+09	3,02E+11	3,73E+11
2,25E+00	5,80E+10	3,96E+09	2,46E+11	3,50E+11
2,50E+00	5,37E+10	3,88E+09	2,04E+11	3,31E+11
2,75E+00	5,05E+10	3,80E+09	1,73E+11	3,16E+11
3,00E+00	4,78E+10	3,73E+09	1,48E+11	3,03E+11
3,25E+00	4,55E+10	3,68E+09	1,29E+11	2,92E+11
3,50E+00	4,35E+10	3,63E+09	1,14E+11	2,83E+11
3,75E+00	4,18E+10	3,59E+09	1,01E+11	2,75E+11
4,00E+00	4,04E+10	3,55E+09	9,09E+10	2,67E+11
4,25E+00	3,90E+10	3,51E+09	8,19E+10	2,60E+11
4,50E+00	3,79E+10	3,47E+09	7,51E+10	2,54E+11
4,75E+00	3,69E+10	3,43E+09	6,90E+10	2,49E+11
5,00E+00	3,60E+10	3,39E+09	6,36E+10	2,44E+11
5,25E+00	3,51E+10	3,36E+09	5,92E+10	2,40E+11
5,50E+00	3,43E+10	3,32E+09	5,52E+10	2,36E+11
5,75E+00	3,35E+10	3,29E+09	5,17E+10	2,32E+11
6,00E+00	3,28E+10	3,25E+09	4,85E+10	2,28E+11
6,25E+00	3,22E+10	3,22E+09	4,56E+10	2,25E+11
6,50E+00	3,16E+10	3,18E+09	4,31E+10	2,22E+11
6,75E+00	3,10E+10	3,15E+09	4,07E+10	2,19E+11
7,00E+00	3,05E+10	3,12E+09	3,87E+10	2,17E+11
7,25E+00	3,00E+10	3,09E+09	3,69E+10	2,14E+11
7,50E+00	2,95E+10	3,06E+09	3,53E+10	2,12E+11
7,75E+00	2,91E+10	3,04E+09	3,38E+10	2,09E+11
8,00E+00	2,87E+10	3,01E+09	3,24E+10	2,07E+11

Al Thickness [mm]	Displacement Damages expressed in Equivalent 50 Mev Protons Fluence [cm ⁻²]			
	800 km 98° 10 years Reference	400 km 33° 10 years	GEO 18 years	JASON 2 10 years
8,25E+00	2,83E+10	2,98E+09	3,11E+10	2,05E+11
8,50E+00	2,79E+10	2,96E+09	2,99E+10	2,02E+11
8,75E+00	2,75E+10	2,94E+09	2,88E+10	2,00E+11
9,00E+00	2,72E+10	2,91E+09	2,77E+10	1,98E+11
9,50E+00	2,65E+10	2,87E+09	2,58E+10	1,94E+11
1,00E+01	2,59E+10	2,83E+09	2,41E+10	1,90E+11
1,05E+01	2,53E+10	2,79E+09	2,25E+10	1,86E+11
1,10E+01	2,48E+10	2,75E+09	2,12E+10	1,83E+11
1,15E+01	2,43E+10	2,71E+09	2,00E+10	1,80E+11
1,20E+01	2,38E+10	2,67E+09	1,89E+10	1,77E+11
1,25E+01	2,33E+10	2,63E+09	1,79E+10	1,74E+11
1,30E+01	2,29E+10	2,60E+09	1,70E+10	1,71E+11
1,35E+01	2,25E+10	2,56E+09	1,61E+10	1,69E+11
1,40E+01	2,21E+10	2,52E+09	1,53E+10	1,66E+11
1,45E+01	2,17E+10	2,49E+09	1,46E+10	1,64E+11
1,50E+01	2,13E+10	2,45E+09	1,39E+10	1,61E+11
1,60E+01	2,07E+10	2,39E+09	1,27E+10	1,57E+11
1,70E+01	2,00E+10	2,33E+09	1,17E+10	1,53E+11
1,80E+01	1,94E+10	2,27E+09	1,08E+10	1,49E+11
1,90E+01	1,89E+10	2,21E+09	9,96E+09	1,45E+11
2,00E+01	1,83E+10	2,16E+09	9,26E+09	1,41E+11
3,00E+01	1,44E+10	1,63E+09	5,07E+09	1,13E+11
4,00E+01	1,14E+10	1,33E+09	3,17E+09	9,06E+10
5,00E+01	9,53E+09	9,67E+08	2,21E+09	7,61E+10
1,00E+02	4,21E+09	2,57E+08	6,29E+08	3,42E+10

Table 449. Worst case displacement damage dose in GaAs expressed in terms of equivalent 50 MeV proton fluence.

Al Thickness [mm]	Displacement Damages expressed in Equivalent 50 MeV Protons Fluence [cm ⁻²]			
	800 km 98° 10 years Reference	400 km 33° 10 years	GEO 18 years	JASON 2 10 years
1,00E-02	1,18E+13	1,74E+10	1,81E+14	6,00E+13
1,00E-01	1,37E+12	9,24E+09	1,17E+13	4,72E+12
2,00E-01	6,87E+11	8,09E+09	7,21E+12	2,66E+12
3,00E-01	4,67E+11	7,47E+09	5,28E+12	1,94E+12
4,00E-01	3,58E+11	6,95E+09	4,11E+12	1,57E+12
5,00E-01	2,92E+11	6,45E+09	3,31E+12	1,33E+12
6,00E-01	2,46E+11	6,07E+09	2,72E+12	1,16E+12
7,00E-01	2,14E+11	5,78E+09	2,28E+12	1,04E+12
8,00E-01	1,90E+11	5,57E+09	1,93E+12	9,44E+11
9,00E-01	1,71E+11	5,43E+09	1,65E+12	8,65E+11
1,00E+00	1,56E+11	5,36E+09	1,43E+12	7,99E+11
1,10E+00	1,43E+11	5,27E+09	1,25E+12	7,41E+11
1,20E+00	1,32E+11	5,20E+09	1,09E+12	6,92E+11
1,30E+00	1,23E+11	5,14E+09	9,65E+11	6,49E+11
1,40E+00	1,15E+11	5,08E+09	8,59E+11	6,13E+11
1,50E+00	1,08E+11	5,01E+09	7,67E+11	5,80E+11
1,60E+00	1,01E+11	4,94E+09	6,89E+11	5,49E+11
1,70E+00	9,61E+10	4,86E+09	6,19E+11	5,25E+11
1,80E+00	9,12E+10	4,78E+09	5,60E+11	5,04E+11
1,90E+00	8,69E+10	4,71E+09	5,09E+11	4,84E+11
2,00E+00	8,30E+10	4,64E+09	4,64E+11	4,67E+11
2,25E+00	7,49E+10	4,49E+09	3,76E+11	4,31E+11
2,50E+00	6,83E+10	4,37E+09	3,09E+11	4,02E+11
2,75E+00	6,33E+10	4,27E+09	2,59E+11	3,79E+11
3,00E+00	5,90E+10	4,17E+09	2,19E+11	3,60E+11
3,25E+00	5,56E+10	4,10E+09	1,89E+11	3,43E+11
3,50E+00	5,27E+10	4,04E+09	1,66E+11	3,29E+11
3,75E+00	5,02E+10	3,99E+09	1,45E+11	3,17E+11
4,00E+00	4,80E+10	3,94E+09	1,30E+11	3,06E+11
4,25E+00	4,61E+10	3,88E+09	1,16E+11	2,97E+11
4,50E+00	4,45E+10	3,84E+09	1,05E+11	2,88E+11
4,75E+00	4,31E+10	3,79E+09	9,59E+10	2,81E+11
5,00E+00	4,17E+10	3,75E+09	8,78E+10	2,74E+11
5,25E+00	4,05E+10	3,70E+09	8,12E+10	2,68E+11
5,50E+00	3,94E+10	3,66E+09	7,51E+10	2,62E+11
5,75E+00	3,83E+10	3,61E+09	7,00E+10	2,57E+11
6,00E+00	3,74E+10	3,57E+09	6,52E+10	2,53E+11
6,25E+00	3,65E+10	3,52E+09	6,09E+10	2,49E+11
6,50E+00	3,57E+10	3,48E+09	5,72E+10	2,45E+11
6,75E+00	3,49E+10	3,44E+09	5,38E+10	2,41E+11
7,00E+00	3,42E+10	3,40E+09	5,09E+10	2,38E+11
7,25E+00	3,36E+10	3,36E+09	4,82E+10	2,34E+11
7,50E+00	3,30E+10	3,33E+09	4,59E+10	2,31E+11
7,75E+00	3,24E+10	3,30E+09	4,38E+10	2,28E+11
8,00E+00	3,19E+10	3,27E+09	4,19E+10	2,25E+11

Al Thickness [mm]	Displacement Damages expressed in Equivalent 50 MeV Protons Fluence [cm ⁻²]			
	800 km 98° 10 years Reference	400 km 33° 10 years	GEO 18 years	JASON 2 10 years
8,25E+00	3,14E+10	3,24E+09	4,01E+10	2,23E+11
8,50E+00	3,09E+10	3,21E+09	3,84E+10	2,20E+11
8,75E+00	3,04E+10	3,18E+09	3,68E+10	2,17E+11
9,00E+00	2,99E+10	3,15E+09	3,54E+10	2,15E+11
9,50E+00	2,91E+10	3,11E+09	3,27E+10	2,09E+11
1,00E+01	2,83E+10	3,06E+09	3,03E+10	2,05E+11
1,05E+01	2,76E+10	3,01E+09	2,83E+10	2,00E+11
1,10E+01	2,69E+10	2,97E+09	2,64E+10	1,96E+11
1,15E+01	2,63E+10	2,92E+09	2,49E+10	1,93E+11
1,20E+01	2,57E+10	2,88E+09	2,34E+10	1,89E+11
1,25E+01	2,52E+10	2,84E+09	2,20E+10	1,86E+11
1,30E+01	2,47E+10	2,80E+09	2,08E+10	1,82E+11
1,35E+01	2,42E+10	2,76E+09	1,97E+10	1,79E+11
1,40E+01	2,37E+10	2,71E+09	1,86E+10	1,76E+11
1,45E+01	2,32E+10	2,68E+09	1,77E+10	1,73E+11
1,50E+01	2,28E+10	2,64E+09	1,68E+10	1,71E+11
1,60E+01	2,20E+10	2,56E+09	1,53E+10	1,66E+11
1,70E+01	2,13E+10	2,49E+09	1,39E+10	1,61E+11
1,80E+01	2,06E+10	2,42E+09	1,28E+10	1,56E+11
1,90E+01	1,99E+10	2,36E+09	1,18E+10	1,52E+11
2,00E+01	1,93E+10	2,30E+09	1,09E+10	1,48E+11
3,00E+01	1,50E+10	1,74E+09	5,74E+09	1,17E+11
4,00E+01	1,18E+10	1,41E+09	3,50E+09	9,33E+10
5,00E+01	9,77E+09	1,05E+09	2,38E+09	7,79E+10
1,00E+02	4,31E+09	3,02E+08	6,58E+08	3,50E+10

Table 5510. LET spectrum. GCRs and solar flare heavy ions. GEO worst case is included for comparison purposes.

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,6943E+00	1,6577E+00	1,8005E+03	7,7651E+03
1,7130E+00	1,5597E+00	1,8004E+03	7,7648E+03
1,7320E+00	1,4676E+00	1,8004E+03	7,7644E+03
1,7512E+00	1,3809E+00	1,8003E+03	7,7641E+03
1,7707E+00	1,2993E+00	1,8003E+03	7,7638E+03
1,7903E+00	1,2225E+00	1,8003E+03	7,7635E+03
1,8101E+00	1,1503E+00	1,8002E+03	7,7632E+03
1,8302E+00	1,0823E+00	1,8002E+03	7,7629E+03
1,8505E+00	1,0184E+00	1,8002E+03	7,7625E+03
1,8710E+00	9,5819E-01	1,8001E+03	7,7622E+03
1,8918E+00	9,0158E-01	1,8001E+03	7,7619E+03
1,9127E+00	8,5968E-01	1,8000E+03	7,7616E+03
1,9340E+00	8,2096E-01	1,7999E+03	7,7612E+03
1,9554E+00	7,8399E-01	1,7998E+03	7,7608E+03
1,9771E+00	7,4868E-01	1,7998E+03	7,7604E+03
1,9990E+00	7,1496E-01	1,7997E+03	7,7601E+03
2,0212E+00	6,8276E-01	1,7996E+03	7,7597E+03
2,0436E+00	6,5200E-01	1,7995E+03	7,7593E+03
2,0662E+00	6,2264E-01	1,7994E+03	7,7589E+03
2,0891E+00	5,9459E-01	1,7993E+03	7,7586E+03
2,1123E+00	5,6781E-01	1,7993E+03	7,7582E+03
2,1357E+00	5,5311E-01	1,7991E+03	7,7576E+03
2,1594E+00	5,4150E-01	1,7990E+03	7,7570E+03
2,1834E+00	5,3013E-01	1,7988E+03	7,7564E+03
2,2076E+00	5,1900E-01	1,7987E+03	7,7558E+03
2,2320E+00	5,0811E-01	1,7985E+03	7,7552E+03
2,2568E+00	4,9744E-01	1,7983E+03	7,7546E+03
2,2818E+00	4,8700E-01	1,7982E+03	7,7540E+03
2,3071E+00	4,7678E-01	1,7980E+03	7,7534E+03
2,3327E+00	4,6677E-01	1,7979E+03	7,7528E+03
2,3586E+00	4,5697E-01	1,7977E+03	7,7522E+03
2,3847E+00	4,4847E-01	1,7975E+03	7,7512E+03
2,4112E+00	4,4060E-01	1,7972E+03	7,7501E+03
2,4379E+00	4,3286E-01	1,7969E+03	7,7490E+03
2,4649E+00	4,2526E-01	1,7966E+03	7,7479E+03
2,4922E+00	4,1779E-01	1,7963E+03	7,7468E+03
2,5199E+00	4,1045E-01	1,7961E+03	7,7458E+03
2,5478E+00	4,0325E-01	1,7958E+03	7,7447E+03
2,5761E+00	3,9616E-01	1,7955E+03	7,7436E+03
2,6046E+00	3,8921E-01	1,7952E+03	7,7425E+03
2,6335E+00	3,8237E-01	1,7949E+03	7,7414E+03
2,6627E+00	3,7646E-01	1,7945E+03	7,7399E+03
2,6922E+00	3,7118E-01	1,7941E+03	7,7382E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
2,7221E+00	3,6598E-01	1,7937E+03	7,7364E+03
2,7523E+00	3,6085E-01	1,7932E+03	7,7347E+03
2,7828E+00	3,5579E-01	1,7928E+03	7,7330E+03
2,8136E+00	3,5080E-01	1,7923E+03	7,7312E+03
2,8448E+00	3,4588E-01	1,7919E+03	7,7295E+03
2,8764E+00	3,4103E-01	1,7914E+03	7,7278E+03
2,9083E+00	3,3625E-01	1,7910E+03	7,7260E+03
2,9405E+00	3,3153E-01	1,7906E+03	7,7243E+03
2,9731E+00	3,2704E-01	1,7900E+03	7,7220E+03
3,0061E+00	3,2276E-01	1,7893E+03	7,7192E+03
3,0394E+00	3,1854E-01	1,7886E+03	7,7164E+03
3,0731E+00	3,1438E-01	1,7878E+03	7,7136E+03
3,1072E+00	3,1027E-01	1,7871E+03	7,7108E+03
3,1417E+00	3,0621E-01	1,7864E+03	7,7080E+03
3,1765E+00	3,0220E-01	1,7857E+03	7,7052E+03
3,2117E+00	2,9825E-01	1,7850E+03	7,7024E+03
3,2473E+00	2,9435E-01	1,7843E+03	7,6996E+03
3,2833E+00	2,9050E-01	1,7836E+03	7,6968E+03
3,3197E+00	2,8709E-01	1,7828E+03	7,6936E+03
3,3565E+00	2,8430E-01	1,7819E+03	7,6898E+03
3,3938E+00	2,8154E-01	1,7809E+03	7,6861E+03
3,4314E+00	2,7880E-01	1,7800E+03	7,6824E+03
3,4694E+00	2,7610E-01	1,7790E+03	7,6786E+03
3,5079E+00	2,7341E-01	1,7781E+03	7,6749E+03
3,5468E+00	2,7076E-01	1,7772E+03	7,6711E+03
3,5861E+00	2,6813E-01	1,7762E+03	7,6674E+03
3,6259E+00	2,6552E-01	1,7753E+03	7,6637E+03
3,6661E+00	2,6294E-01	1,7744E+03	7,6599E+03
3,7067E+00	2,6051E-01	1,7733E+03	7,6557E+03
3,7478E+00	2,5838E-01	1,7720E+03	7,6502E+03
3,7894E+00	2,5626E-01	1,7706E+03	7,6447E+03
3,8314E+00	2,5417E-01	1,7692E+03	7,6392E+03
3,8739E+00	2,5209E-01	1,7679E+03	7,6337E+03
3,9168E+00	2,5002E-01	1,7665E+03	7,6282E+03
3,9603E+00	2,4798E-01	1,7652E+03	7,6227E+03
4,0042E+00	2,4595E-01	1,7638E+03	7,6172E+03
4,0486E+00	2,4394E-01	1,7625E+03	7,6118E+03
4,0935E+00	2,4194E-01	1,7611E+03	7,6063E+03
4,1389E+00	2,4002E-01	1,7596E+03	7,6004E+03
4,1847E+00	2,3836E-01	1,7577E+03	7,5926E+03
4,2311E+00	2,3671E-01	1,7558E+03	7,5849E+03
4,2781E+00	2,3508E-01	1,7539E+03	7,5771E+03
4,3255E+00	2,3345E-01	1,7520E+03	7,5694E+03
4,3735E+00	2,3184E-01	1,7502E+03	7,5616E+03
4,4219E+00	2,3023E-01	1,7483E+03	7,5539E+03
4,4710E+00	2,2864E-01	1,7464E+03	7,5462E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
4,5206E+00	2,2706E-01	1,7445E+03	7,5385E+03
4,5707E+00	2,2549E-01	1,7426E+03	7,5308E+03
4,6214E+00	2,2395E-01	1,7406E+03	7,5228E+03
4,6726E+00	2,2265E-01	1,7380E+03	7,5119E+03
4,7244E+00	2,2135E-01	1,7353E+03	7,5010E+03
4,7768E+00	2,2007E-01	1,7327E+03	7,4901E+03
4,8298E+00	2,1879E-01	1,7301E+03	7,4792E+03
4,8833E+00	2,1752E-01	1,7274E+03	7,4683E+03
4,9375E+00	2,1625E-01	1,7248E+03	7,4575E+03
4,9922E+00	2,1500E-01	1,7222E+03	7,4466E+03
5,0475E+00	2,1375E-01	1,7196E+03	7,4358E+03
5,1035E+00	2,1250E-01	1,7169E+03	7,4250E+03
5,1601E+00	2,1127E-01	1,7143E+03	7,4142E+03
5,2173E+00	2,1032E-01	1,7110E+03	7,4003E+03
5,2752E+00	2,0938E-01	1,7076E+03	7,3864E+03
5,3337E+00	2,0845E-01	1,7043E+03	7,3725E+03
5,3928E+00	2,0752E-01	1,7010E+03	7,3587E+03
5,4526E+00	2,0659E-01	1,6976E+03	7,3449E+03
5,5130E+00	2,0567E-01	1,6943E+03	7,3311E+03
5,5742E+00	2,0475E-01	1,6910E+03	7,3173E+03
5,6360E+00	2,0384E-01	1,6877E+03	7,3035E+03
5,6985E+00	2,0293E-01	1,6844E+03	7,2898E+03
5,7617E+00	2,0203E-01	1,6811E+03	7,2761E+03
5,8255E+00	2,0131E-01	1,6771E+03	7,2593E+03
5,8901E+00	2,0062E-01	1,6730E+03	7,2422E+03
5,9554E+00	1,9993E-01	1,6689E+03	7,2251E+03
6,0215E+00	1,9924E-01	1,6649E+03	7,2080E+03
6,0882E+00	1,9856E-01	1,6608E+03	7,1910E+03
6,1557E+00	1,9788E-01	1,6567E+03	7,1740E+03
6,2240E+00	1,9720E-01	1,6527E+03	7,1570E+03
6,2930E+00	1,9652E-01	1,6487E+03	7,1401E+03
6,3628E+00	1,9585E-01	1,6446E+03	7,1233E+03
6,4333E+00	1,9518E-01	1,6406E+03	7,1065E+03
6,5047E+00	1,9141E-01	1,6354E+03	7,0844E+03
6,5768E+00	1,8690E-01	1,6299E+03	7,0611E+03
6,6497E+00	1,8250E-01	1,6243E+03	7,0378E+03
6,7234E+00	1,7821E-01	1,6188E+03	7,0146E+03
6,7980E+00	1,7401E-01	1,6133E+03	6,9915E+03
6,8734E+00	1,6991E-01	1,6079E+03	6,9684E+03
6,9496E+00	1,6591E-01	1,6024E+03	6,9455E+03
7,0266E+00	1,6201E-01	1,5970E+03	6,9226E+03
7,1045E+00	1,5819E-01	1,5916E+03	6,8998E+03
7,1833E+00	1,5447E-01	1,5862E+03	6,8770E+03
7,2630E+00	1,4838E-01	1,5800E+03	6,8508E+03
7,3435E+00	1,4147E-01	1,5734E+03	6,8230E+03
7,4249E+00	1,3487E-01	1,5669E+03	6,7954E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
7,5073E+00	1,2859E-01	1,5604E+03	6,7678E+03
7,5905E+00	1,2260E-01	1,5540E+03	6,7404E+03
7,6747E+00	1,1689E-01	1,5475E+03	6,7131E+03
7,7597E+00	1,1144E-01	1,5411E+03	6,6859E+03
7,8458E+00	1,0625E-01	1,5347E+03	6,6588E+03
7,9328E+00	1,0130E-01	1,5283E+03	6,6318E+03
8,0207E+00	9,6578E-02	1,5220E+03	6,6049E+03
8,1097E+00	9,3316E-02	1,5148E+03	6,5744E+03
8,1996E+00	9,1021E-02	1,5071E+03	6,5415E+03
8,2905E+00	8,8781E-02	1,4994E+03	6,5086E+03
8,3824E+00	8,6597E-02	1,4917E+03	6,4760E+03
8,4754E+00	8,4467E-02	1,4841E+03	6,4435E+03
8,5693E+00	8,2389E-02	1,4765E+03	6,4112E+03
8,6644E+00	8,0362E-02	1,4689E+03	6,3791E+03
8,7604E+00	7,8385E-02	1,4614E+03	6,3471E+03
8,8576E+00	7,6456E-02	1,4539E+03	6,3152E+03
8,9558E+00	7,4575E-02	1,4465E+03	6,2836E+03
9,0551E+00	7,2956E-02	1,4384E+03	6,2489E+03
9,1555E+00	7,1597E-02	1,4295E+03	6,2111E+03
9,2570E+00	7,0263E-02	1,4207E+03	6,1735E+03
9,3596E+00	6,8955E-02	1,4120E+03	6,1361E+03
9,4634E+00	6,7670E-02	1,4033E+03	6,0990E+03
9,5683E+00	6,6410E-02	1,3946E+03	6,0621E+03
9,6744E+00	6,5172E-02	1,3860E+03	6,0254E+03
9,7817E+00	6,3958E-02	1,3775E+03	5,9890E+03
9,8902E+00	6,2767E-02	1,3690E+03	5,9527E+03
9,9998E+00	6,1598E-02	1,3606E+03	5,9167E+03
1,0111E+01	6,0501E-02	1,3518E+03	5,8789E+03
1,0223E+01	5,9505E-02	1,3423E+03	5,8381E+03
1,0336E+01	5,8525E-02	1,3328E+03	5,7977E+03
1,0451E+01	5,7561E-02	1,3234E+03	5,7575E+03
1,0567E+01	5,6613E-02	1,3141E+03	5,7176E+03
1,0684E+01	5,5681E-02	1,3049E+03	5,6780E+03
1,0802E+01	5,4764E-02	1,2957E+03	5,6386E+03
1,0922E+01	5,3862E-02	1,2866E+03	5,5995E+03
1,1043E+01	5,2975E-02	1,2775E+03	5,5607E+03
1,1166E+01	5,2103E-02	1,2685E+03	5,5222E+03
1,1289E+01	5,1250E-02	1,2591E+03	5,4816E+03
1,1415E+01	5,0424E-02	1,2483E+03	5,4354E+03
1,1541E+01	4,9612E-02	1,2377E+03	5,3897E+03
1,1669E+01	4,8813E-02	1,2271E+03	5,3443E+03
1,1798E+01	4,8026E-02	1,2166E+03	5,2993E+03
1,1929E+01	4,7253E-02	1,2063E+03	5,2547E+03
1,2062E+01	4,6492E-02	1,1960E+03	5,2105E+03
1,2195E+01	4,5743E-02	1,1858E+03	5,1666E+03
1,2331E+01	4,5006E-02	1,1756E+03	5,1231E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,2467E+01	4,4281E-02	1,1656E+03	5,0800E+03
1,2605E+01	4,3588E-02	1,1554E+03	5,0362E+03
1,2745E+01	4,2998E-02	1,1443E+03	4,9883E+03
1,2887E+01	4,2415E-02	1,1333E+03	4,9408E+03
1,3029E+01	4,1840E-02	1,1223E+03	4,8937E+03
1,3174E+01	4,1273E-02	1,1115E+03	4,8472E+03
1,3320E+01	4,0714E-02	1,1008E+03	4,8010E+03
1,3468E+01	4,0162E-02	1,0902E+03	4,7553E+03
1,3617E+01	3,9618E-02	1,0797E+03	4,7101E+03
1,3768E+01	3,9081E-02	1,0693E+03	4,6652E+03
1,3921E+01	3,8552E-02	1,0590E+03	4,6208E+03
1,4075E+01	3,8033E-02	1,0486E+03	4,5760E+03
1,4231E+01	3,7562E-02	1,0362E+03	4,5223E+03
1,4389E+01	3,7097E-02	1,0239E+03	4,4693E+03
1,4548E+01	3,6638E-02	1,0118E+03	4,4169E+03
1,4710E+01	3,6185E-02	9,9981E+02	4,3651E+03
1,4873E+01	3,5737E-02	9,8797E+02	4,3140E+03
1,5038E+01	3,5295E-02	9,7627E+02	4,2634E+03
1,5204E+01	3,4858E-02	9,6471E+02	4,2134E+03
1,5373E+01	3,4426E-02	9,5329E+02	4,1640E+03
1,5543E+01	3,4000E-02	9,4200E+02	4,1152E+03
1,5716E+01	3,3579E-02	9,3084E+02	4,0669E+03
1,5890E+01	3,3159E-02	9,1832E+02	4,0127E+03
1,6066E+01	3,2743E-02	9,0595E+02	3,9590E+03
1,6244E+01	3,2333E-02	8,9373E+02	3,9061E+03
1,6425E+01	3,1928E-02	8,8169E+02	3,8538E+03
1,6607E+01	3,1528E-02	8,6980E+02	3,8023E+03
1,6791E+01	3,1133E-02	8,5808E+02	3,7514E+03
1,6977E+01	3,0743E-02	8,4651E+02	3,7013E+03
1,7165E+01	3,0358E-02	8,3510E+02	3,6518E+03
1,7356E+01	2,9978E-02	8,2385E+02	3,6029E+03
1,7548E+01	2,9602E-02	8,1274E+02	3,5547E+03
1,7743E+01	2,9275E-02	8,0128E+02	3,5049E+03
1,7939E+01	2,8958E-02	7,8990E+02	3,4554E+03
1,8138E+01	2,8644E-02	7,7869E+02	3,4067E+03
1,8339E+01	2,8334E-02	7,6764E+02	3,3586E+03
1,8543E+01	2,8027E-02	7,5674E+02	3,3112E+03
1,8748E+01	2,7724E-02	7,4600E+02	3,2645E+03
1,8956E+01	2,7423E-02	7,3541E+02	3,2184E+03
1,9166E+01	2,7126E-02	7,2497E+02	3,1730E+03
1,9379E+01	2,6832E-02	7,1468E+02	3,1283E+03
1,9594E+01	2,6541E-02	7,0454E+02	3,0841E+03
1,9811E+01	2,6286E-02	6,9383E+02	3,0375E+03
2,0031E+01	2,6043E-02	6,8310E+02	2,9907E+03
2,0253E+01	2,5802E-02	6,7253E+02	2,9446E+03
2,0477E+01	2,5563E-02	6,6213E+02	2,8993E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
2,0704E+01	2,5326E-02	6,5188E+02	2,8546E+03
2,0934E+01	2,5091E-02	6,4180E+02	2,8107E+03
2,1166E+01	2,4859E-02	6,3187E+02	2,7674E+03
2,1401E+01	2,4629E-02	6,2209E+02	2,7248E+03
2,1638E+01	2,4401E-02	6,1246E+02	2,6828E+03
2,1878E+01	2,4175E-02	6,0299E+02	2,6415E+03
2,2120E+01	2,3975E-02	5,9284E+02	2,5972E+03
2,2366E+01	2,3787E-02	5,8247E+02	2,5519E+03
2,2614E+01	2,3601E-02	5,7228E+02	2,5074E+03
2,2864E+01	2,3417E-02	5,6227E+02	2,4637E+03
2,3118E+01	2,3234E-02	5,5244E+02	2,4208E+03
2,3374E+01	2,3052E-02	5,4278E+02	2,3786E+03
2,3633E+01	2,2872E-02	5,3328E+02	2,3371E+03
2,3895E+01	2,2693E-02	5,2396E+02	2,2964E+03
2,4160E+01	2,2515E-02	5,1479E+02	2,2564E+03
2,4428E+01	2,2339E-02	5,0579E+02	2,2170E+03
2,4699E+01	2,2177E-02	4,9653E+02	2,1765E+03
2,4973E+01	2,2025E-02	4,8714E+02	2,1355E+03
2,5250E+01	2,1874E-02	4,7792E+02	2,0952E+03
2,5530E+01	2,1724E-02	4,6888E+02	2,0557E+03
2,5813E+01	2,1575E-02	4,6001E+02	2,0169E+03
2,6099E+01	2,1427E-02	4,5131E+02	1,9788E+03
2,6389E+01	2,1280E-02	4,4278E+02	1,9415E+03
2,6681E+01	2,1134E-02	4,3440E+02	1,9048E+03
2,6977E+01	2,0989E-02	4,2619E+02	1,8689E+03
2,7276E+01	2,0845E-02	4,1812E+02	1,8336E+03
2,7579E+01	2,0700E-02	4,0987E+02	1,7975E+03
2,7884E+01	2,0553E-02	4,0141E+02	1,7605E+03
2,8193E+01	2,0407E-02	3,9313E+02	1,7242E+03
2,8506E+01	2,0262E-02	3,8501E+02	1,6887E+03
2,8822E+01	2,0118E-02	3,7707E+02	1,6539E+03
2,9142E+01	1,9975E-02	3,6928E+02	1,6198E+03
2,9465E+01	1,9833E-02	3,6166E+02	1,5864E+03
2,9792E+01	1,9693E-02	3,5419E+02	1,5537E+03
3,0122E+01	1,9553E-02	3,4688E+02	1,5217E+03
3,0456E+01	1,9414E-02	3,3972E+02	1,4904E+03
3,0794E+01	1,9289E-02	3,3277E+02	1,4599E+03
3,1135E+01	1,9185E-02	3,2606E+02	1,4305E+03
3,1480E+01	1,9082E-02	3,1948E+02	1,4017E+03
3,1829E+01	1,8979E-02	3,1304E+02	1,3734E+03
3,2182E+01	1,8877E-02	3,0673E+02	1,3458E+03
3,2539E+01	1,8776E-02	3,0054E+02	1,3187E+03
3,2900E+01	1,8675E-02	2,9448E+02	1,2921E+03
3,3265E+01	1,8575E-02	2,8854E+02	1,2661E+03
3,3633E+01	1,8475E-02	2,8272E+02	1,2405E+03
3,4006E+01	1,8375E-02	2,7702E+02	1,2156E+03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
3,4383E+01	1,8282E-02	2,7145E+02	1,1912E+03
3,4765E+01	1,8202E-02	2,6604E+02	1,1675E+03
3,5150E+01	1,8122E-02	2,6075E+02	1,1442E+03
3,5540E+01	1,8043E-02	2,5556E+02	1,1215E+03
3,5934E+01	1,7965E-02	2,5047E+02	1,0992E+03
3,6332E+01	1,7886E-02	2,4548E+02	1,0773E+03
3,6735E+01	1,7808E-02	2,4060E+02	1,0559E+03
3,7143E+01	1,7730E-02	2,3581E+02	1,0348E+03
3,7554E+01	1,7653E-02	2,3111E+02	1,0143E+03
3,7971E+01	1,7576E-02	2,2651E+02	9,9408E+02
3,8392E+01	1,7501E-02	2,2193E+02	9,7400E+02
3,8817E+01	1,7438E-02	2,1711E+02	9,5285E+02
3,9248E+01	1,7375E-02	2,1240E+02	9,3217E+02
3,9683E+01	1,7312E-02	2,0779E+02	9,1194E+02
4,0123E+01	1,7249E-02	2,0328E+02	8,9214E+02
4,0568E+01	1,7186E-02	1,9886E+02	8,7277E+02
4,1018E+01	1,7124E-02	1,9454E+02	8,5383E+02
4,1473E+01	1,7062E-02	1,9032E+02	8,3529E+02
4,1932E+01	1,7000E-02	1,8619E+02	8,1716E+02
4,2397E+01	1,6938E-02	1,8215E+02	7,9942E+02
4,2867E+01	1,6873E-02	1,7818E+02	7,8204E+02
4,3343E+01	1,6764E-02	1,7422E+02	7,6463E+02
4,3823E+01	1,6656E-02	1,7034E+02	7,4761E+02
4,4309E+01	1,6548E-02	1,6655E+02	7,3097E+02
4,4800E+01	1,6441E-02	1,6284E+02	7,1470E+02
4,5297E+01	1,6335E-02	1,5922E+02	6,9880E+02
4,5799E+01	1,6229E-02	1,5568E+02	6,8324E+02
4,6307E+01	1,6124E-02	1,5221E+02	6,6804E+02
4,6821E+01	1,6020E-02	1,4883E+02	6,5317E+02
4,7340E+01	1,5916E-02	1,4551E+02	6,3863E+02
4,7865E+01	1,5814E-02	1,4228E+02	6,2442E+02
4,8396E+01	1,5746E-02	1,3910E+02	6,1046E+02
4,8932E+01	1,5679E-02	1,3599E+02	5,9682E+02
4,9475E+01	1,5613E-02	1,3295E+02	5,8348E+02
5,0023E+01	1,5547E-02	1,2998E+02	5,7044E+02
5,0578E+01	1,5481E-02	1,2708E+02	5,5769E+02
5,1139E+01	1,5416E-02	1,2424E+02	5,4523E+02
5,1706E+01	1,5350E-02	1,2146E+02	5,3304E+02
5,2279E+01	1,5286E-02	1,1875E+02	5,2113E+02
5,2859E+01	1,5221E-02	1,1610E+02	5,0948E+02
5,3445E+01	1,5157E-02	1,1350E+02	4,9810E+02
5,4037E+01	1,5108E-02	1,1088E+02	4,8659E+02
5,4637E+01	1,5061E-02	1,0831E+02	4,7529E+02
5,5242E+01	1,5014E-02	1,0580E+02	4,6426E+02
5,5855E+01	1,4968E-02	1,0334E+02	4,5348E+02
5,6474E+01	1,4922E-02	1,0095E+02	4,4295E+02

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
5,7100E+01	1,4876E-02	9,8604E+01	4,3267E+02
5,7733E+01	1,4830E-02	9,6316E+01	4,2262E+02
5,8374E+01	1,4784E-02	9,4082E+01	4,1281E+02
5,9021E+01	1,4738E-02	9,1899E+01	4,0323E+02
5,9675E+01	1,4693E-02	8,9767E+01	3,9387E+02
6,0337E+01	1,4524E-02	8,7643E+01	3,8454E+02
6,1006E+01	1,4321E-02	8,5557E+01	3,7538E+02
6,1682E+01	1,4121E-02	8,3521E+01	3,6644E+02
6,2366E+01	1,3923E-02	8,1534E+01	3,5771E+02
6,3058E+01	1,3728E-02	7,9593E+01	3,4919E+02
6,3757E+01	1,3536E-02	7,7699E+01	3,4088E+02
6,4464E+01	1,3347E-02	7,5850E+01	3,3276E+02
6,5179E+01	1,3160E-02	7,4045E+01	3,2483E+02
6,5901E+01	1,2976E-02	7,2283E+01	3,1710E+02
6,6632E+01	1,2794E-02	7,0562E+01	3,0954E+02
6,7371E+01	1,2638E-02	6,8879E+01	3,0215E+02
6,8118E+01	1,2495E-02	6,7233E+01	2,9493E+02
6,8873E+01	1,2354E-02	6,5626E+01	2,8787E+02
6,9637E+01	1,2214E-02	6,4058E+01	2,8099E+02
7,0409E+01	1,2076E-02	6,2528E+01	2,7427E+02
7,1190E+01	1,1939E-02	6,1034E+01	2,6771E+02
7,1979E+01	1,1804E-02	5,9575E+01	2,6131E+02
7,2777E+01	1,1670E-02	5,8152E+01	2,5506E+02
7,3584E+01	1,1538E-02	5,6762E+01	2,4896E+02
7,4400E+01	1,1408E-02	5,5406E+01	2,4300E+02
7,5225E+01	1,1315E-02	5,4096E+01	2,3725E+02
7,6059E+01	1,1250E-02	5,2826E+01	2,3168E+02
7,6902E+01	1,1186E-02	5,1586E+01	2,2624E+02
7,7755E+01	1,1122E-02	5,0376E+01	2,2092E+02
7,8617E+01	1,1059E-02	4,9194E+01	2,1573E+02
7,9489E+01	1,0996E-02	4,8039E+01	2,1067E+02
8,0370E+01	1,0933E-02	4,6912E+01	2,0572E+02
8,1261E+01	1,0871E-02	4,5811E+01	2,0089E+02
8,2162E+01	1,0809E-02	4,4736E+01	1,9617E+02
8,3073E+01	1,0747E-02	4,3686E+01	1,9156E+02
8,3994E+01	1,0668E-02	4,2632E+01	1,8693E+02
8,4926E+01	1,0569E-02	4,1571E+01	1,8228E+02
8,5867E+01	1,0471E-02	4,0537E+01	1,7774E+02
8,6819E+01	1,0374E-02	3,9529E+01	1,7331E+02
8,7782E+01	1,0277E-02	3,8545E+01	1,6900E+02
8,8755E+01	1,0182E-02	3,7586E+01	1,6479E+02
8,9739E+01	1,0088E-02	3,6651E+01	1,6069E+02
9,0734E+01	9,9940E-03	3,5739E+01	1,5668E+02
9,1741E+01	9,9012E-03	3,4850E+01	1,5278E+02
9,2758E+01	9,8094E-03	3,3983E+01	1,4898E+02
9,3786E+01	9,7296E-03	3,3133E+01	1,4525E+02

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
9,4826E+01	9,6702E-03	3,2296E+01	1,4158E+02
9,5878E+01	9,6111E-03	3,1480E+01	1,3800E+02
9,6941E+01	9,5524E-03	3,0685E+01	1,3451E+02
9,8015E+01	9,4940E-03	2,9910E+01	1,3111E+02
9,9102E+01	9,4360E-03	2,9155E+01	1,2779E+02
1,0020E+02	9,3783E-03	2,8418E+01	1,2456E+02
1,0131E+02	9,3210E-03	2,7700E+01	1,2142E+02
1,0244E+02	9,2640E-03	2,7001E+01	1,1835E+02
1,0357E+02	9,2074E-03	2,6319E+01	1,1536E+02
1,0472E+02	9,1230E-03	2,5656E+01	1,1245E+02
1,0588E+02	8,9614E-03	2,5016E+01	1,0964E+02
1,0705E+02	8,8027E-03	2,4392E+01	1,0690E+02
1,0824E+02	8,6469E-03	2,3784E+01	1,0424E+02
1,0944E+02	8,4937E-03	2,3190E+01	1,0163E+02
1,1066E+02	8,3433E-03	2,2612E+01	9,9096E+01
1,1188E+02	8,1956E-03	2,2048E+01	9,6622E+01
1,1312E+02	8,0504E-03	2,1498E+01	9,4210E+01
1,1438E+02	7,9079E-03	2,0961E+01	9,1858E+01
1,1565E+02	7,7678E-03	2,0438E+01	8,9565E+01
1,1693E+02	7,6239E-03	1,9930E+01	8,7336E+01
1,1822E+02	7,4507E-03	1,9443E+01	8,5198E+01
1,1953E+02	7,2813E-03	1,8967E+01	8,3112E+01
1,2086E+02	7,1158E-03	1,8503E+01	8,1078E+01
1,2220E+02	6,9541E-03	1,8050E+01	7,9093E+01
1,2356E+02	6,7960E-03	1,7609E+01	7,7157E+01
1,2493E+02	6,6416E-03	1,7178E+01	7,5268E+01
1,2631E+02	6,4906E-03	1,6758E+01	7,3425E+01
1,2771E+02	6,3431E-03	1,6348E+01	7,1628E+01
1,2913E+02	6,1989E-03	1,5948E+01	6,9875E+01
1,3056E+02	6,0623E-03	1,5556E+01	6,8156E+01
1,3201E+02	5,9947E-03	1,5145E+01	6,6355E+01
1,3347E+02	5,9277E-03	1,4746E+01	6,4602E+01
1,3495E+02	5,8616E-03	1,4357E+01	6,2895E+01
1,3645E+02	5,7961E-03	1,3978E+01	6,1234E+01
1,3796E+02	5,7314E-03	1,3609E+01	5,9616E+01
1,3949E+02	5,6675E-03	1,3250E+01	5,8041E+01
1,4104E+02	5,6042E-03	1,2900E+01	5,6508E+01
1,4260E+02	5,5416E-03	1,2560E+01	5,5015E+01
1,4418E+02	5,4798E-03	1,2228E+01	5,3561E+01
1,4578E+02	5,4186E-03	1,1906E+01	5,2146E+01
1,4740E+02	5,3709E-03	1,1584E+01	5,0736E+01
1,4903E+02	5,3242E-03	1,1271E+01	4,9363E+01
1,5068E+02	5,2778E-03	1,0966E+01	4,8026E+01
1,5235E+02	5,2319E-03	1,0669E+01	4,6726E+01
1,5404E+02	5,1864E-03	1,0381E+01	4,5461E+01
1,5575E+02	5,1412E-03	1,0100E+01	4,4231E+01

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,5748E+02	5,0965E-03	9,8270E+00	4,3033E+01
1,5922E+02	5,0521E-03	9,5612E+00	4,1868E+01
1,6099E+02	5,0081E-03	9,3027E+00	4,0735E+01
1,6277E+02	4,9646E-03	9,0511E+00	3,9632E+01
1,6458E+02	4,9128E-03	8,7966E+00	3,8516E+01
1,6640E+02	4,8602E-03	8,5478E+00	3,7425E+01
1,6825E+02	4,8082E-03	8,3059E+00	3,6365E+01
1,7011E+02	4,7567E-03	8,0709E+00	3,5335E+01
1,7200E+02	4,7058E-03	7,8425E+00	3,4334E+01
1,7391E+02	4,6554E-03	7,6206E+00	3,3362E+01
1,7584E+02	4,6056E-03	7,4050E+00	3,2417E+01
1,7779E+02	4,5563E-03	7,1955E+00	3,1498E+01
1,7976E+02	4,5075E-03	6,9919E+00	3,0606E+01
1,8175E+02	4,4593E-03	6,7941E+00	2,9739E+01
1,8376E+02	4,4102E-03	6,6067E+00	2,8918E+01
1,8580E+02	4,3613E-03	6,4261E+00	2,8126E+01
1,8786E+02	4,3130E-03	6,2504E+00	2,7356E+01
1,8995E+02	4,2651E-03	6,0795E+00	2,6607E+01
1,9205E+02	4,2178E-03	5,9132E+00	2,5879E+01
1,9418E+02	4,1711E-03	5,7515E+00	2,5170E+01
1,9633E+02	4,1248E-03	5,5943E+00	2,4481E+01
1,9851E+02	4,0791E-03	5,4413E+00	2,3811E+01
2,0071E+02	4,0338E-03	5,2925E+00	2,3159E+01
2,0294E+02	3,9891E-03	5,1478E+00	2,2525E+01
2,0519E+02	3,9524E-03	5,0017E+00	2,1884E+01
2,0746E+02	3,9200E-03	4,8570E+00	2,1250E+01
2,0976E+02	3,8878E-03	4,7164E+00	2,0634E+01
2,1209E+02	3,8559E-03	4,5800E+00	2,0036E+01
2,1444E+02	3,8243E-03	4,4475E+00	1,9456E+01
2,1682E+02	3,7929E-03	4,3188E+00	1,8892E+01
2,1922E+02	3,7618E-03	4,1938E+00	1,8345E+01
2,2165E+02	3,7309E-03	4,0725E+00	1,7813E+01
2,2411E+02	3,7003E-03	3,9547E+00	1,7297E+01
2,2660E+02	3,6699E-03	3,8403E+00	1,6795E+01
2,2911E+02	3,6436E-03	3,7270E+00	1,6299E+01
2,3165E+02	3,6204E-03	3,6153E+00	1,5810E+01
2,3422E+02	3,5973E-03	3,5070E+00	1,5335E+01
2,3681E+02	3,5744E-03	3,4019E+00	1,4875E+01
2,3944E+02	3,5516E-03	3,3000E+00	1,4429E+01
2,4209E+02	3,5290E-03	3,2012E+00	1,3996E+01
2,4478E+02	3,5065E-03	3,1053E+00	1,3576E+01
2,4749E+02	3,4842E-03	3,0122E+00	1,3168E+01
2,5024E+02	3,4620E-03	2,9220E+00	1,2773E+01
2,5301E+02	3,4399E-03	2,8344E+00	1,2390E+01
2,5582E+02	3,3971E-03	2,7491E+00	1,2016E+01
2,5865E+02	3,3301E-03	2,6658E+00	1,1651E+01

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
2,6152E+02	3,2645E-03	2,5850E+00	1,1297E+01
2,6442E+02	3,2002E-03	2,5067E+00	1,0954E+01
2,6735E+02	3,1371E-03	2,4307E+00	1,0621E+01
2,7032E+02	3,0753E-03	2,3571E+00	1,0298E+01
2,7331E+02	3,0147E-03	2,2856E+00	9,9853E+00
2,7634E+02	2,9553E-03	2,2164E+00	9,6820E+00
2,7941E+02	2,8971E-03	2,1492E+00	9,3879E+00
2,8251E+02	2,8400E-03	2,0841E+00	9,1027E+00
2,8564E+02	2,7921E-03	2,0206E+00	8,8246E+00
2,8881E+02	2,7594E-03	1,9584E+00	8,5524E+00
2,9201E+02	2,7271E-03	1,8982E+00	8,2885E+00
2,9525E+02	2,6951E-03	1,8398E+00	8,0327E+00
2,9852E+02	2,6636E-03	1,7832E+00	7,7849E+00
3,0183E+02	2,6324E-03	1,7283E+00	7,5446E+00
3,0518E+02	2,6016E-03	1,6751E+00	7,3118E+00
3,0856E+02	2,5711E-03	1,6236E+00	7,0862E+00
3,1198E+02	2,5410E-03	1,5736E+00	6,8676E+00
3,1544E+02	2,5113E-03	1,5252E+00	6,6557E+00
3,1894E+02	2,4809E-03	1,4773E+00	6,4460E+00
3,2247E+02	2,4479E-03	1,4281E+00	6,2305E+00
3,2605E+02	2,4154E-03	1,3805E+00	6,0222E+00
3,2967E+02	2,3833E-03	1,3346E+00	5,8209E+00
3,3332E+02	2,3516E-03	1,2901E+00	5,6263E+00
3,3702E+02	2,3204E-03	1,2472E+00	5,4382E+00
3,4075E+02	2,2895E-03	1,2056E+00	5,2564E+00
3,4453E+02	2,2591E-03	1,1655E+00	5,0807E+00
3,4835E+02	2,2291E-03	1,1267E+00	4,9109E+00
3,5221E+02	2,1995E-03	1,0891E+00	4,7467E+00
3,5612E+02	2,1685E-03	1,0524E+00	4,5858E+00
3,6007E+02	2,1281E-03	1,0142E+00	4,4187E+00
3,6406E+02	2,0885E-03	9,7742E-01	4,2576E+00
3,6810E+02	2,0497E-03	9,4197E-01	4,1023E+00
3,7218E+02	2,0116E-03	9,0780E-01	3,9528E+00
3,7631E+02	1,9741E-03	8,7488E-01	3,8087E+00
3,8048E+02	1,9374E-03	8,4315E-01	3,6698E+00
3,8470E+02	1,9014E-03	8,1256E-01	3,5360E+00
3,8896E+02	1,8660E-03	7,8309E-01	3,4071E+00
3,9327E+02	1,8313E-03	7,5469E-01	3,2829E+00
3,9764E+02	1,7979E-03	7,2716E-01	3,1625E+00
4,0204E+02	1,7778E-03	6,9772E-01	3,0336E+00
4,0650E+02	1,7578E-03	6,6947E-01	2,9099E+00
4,1101E+02	1,7381E-03	6,4237E-01	2,7913E+00
4,1557E+02	1,7187E-03	6,1637E-01	2,6775E+00
4,2017E+02	1,6994E-03	5,9142E-01	2,5683E+00
4,2483E+02	1,6804E-03	5,6748E-01	2,4636E+00
4,2954E+02	1,6615E-03	5,4451E-01	2,3632E+00

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
4,3431E+02	1,6429E-03	5,2246E-01	2,2669E+00
4,3912E+02	1,6245E-03	5,0131E-01	2,1745E+00
4,4399E+02	1,6063E-03	4,8102E-01	2,0858E+00
4,4891E+02	1,5872E-03	4,5458E-01	1,9698E+00
4,5389E+02	1,5683E-03	4,2924E-01	1,8587E+00
4,5892E+02	1,5496E-03	4,0532E-01	1,7538E+00
4,6401E+02	1,5311E-03	3,8273E-01	1,6549E+00
4,6916E+02	1,5128E-03	3,6139E-01	1,5615E+00
4,7436E+02	1,4948E-03	3,4125E-01	1,4734E+00
4,7962E+02	1,4770E-03	3,2223E-01	1,3903E+00
4,8494E+02	1,4593E-03	3,0427E-01	1,3119E+00
4,9031E+02	1,4419E-03	2,8731E-01	1,2379E+00
4,9575E+02	1,4247E-03	2,7130E-01	1,1680E+00
5,0125E+02	1,4109E-03	2,4425E-01	1,0483E+00
5,0680E+02	1,3977E-03	2,1804E-01	9,3248E-01
5,1242E+02	1,3847E-03	1,9464E-01	8,2945E-01
5,1811E+02	1,3718E-03	1,7376E-01	7,3781E-01
5,2385E+02	1,3590E-03	1,5511E-01	6,5629E-01
5,2966E+02	1,3463E-03	1,3846E-01	5,8378E-01
5,3553E+02	1,3337E-03	1,2360E-01	5,1928E-01
5,4147E+02	1,3213E-03	1,1034E-01	4,6191E-01
5,4747E+02	1,3089E-03	9,8499E-02	4,1087E-01
5,5354E+02	1,2967E-03	8,7929E-02	3,6547E-01
5,5968E+02	1,2847E-03	8,4105E-02	3,4923E-01
5,6589E+02	1,2729E-03	8,2346E-02	3,4188E-01
5,7216E+02	1,2612E-03	8,0624E-02	3,3468E-01
5,7851E+02	1,2496E-03	7,8937E-02	3,2763E-01
5,8492E+02	1,2382E-03	7,7287E-02	3,2073E-01
5,9141E+02	1,2268E-03	7,5670E-02	3,1398E-01
5,9796E+02	1,2155E-03	7,4088E-02	3,0737E-01
6,0459E+02	1,2043E-03	7,2538E-02	3,0090E-01
6,1130E+02	1,1933E-03	7,1021E-02	2,9456E-01
6,1807E+02	1,1823E-03	6,9536E-02	2,8836E-01
6,2493E+02	1,1720E-03	6,8086E-02	2,8231E-01
6,3186E+02	1,1621E-03	6,6669E-02	2,7639E-01
6,3886E+02	1,1523E-03	6,5282E-02	2,7060E-01
6,4595E+02	1,1425E-03	6,3923E-02	2,6493E-01
6,5311E+02	1,1329E-03	6,2593E-02	2,5937E-01
6,6035E+02	1,1233E-03	6,1290E-02	2,5394E-01
6,6767E+02	1,1138E-03	6,0014E-02	2,4861E-01
6,7508E+02	1,1044E-03	5,8765E-02	2,4340E-01
6,8256E+02	1,0951E-03	5,7542E-02	2,3830E-01
6,9013E+02	1,0858E-03	5,6344E-02	2,3331E-01
6,9778E+02	1,0751E-03	5,5187E-02	2,2848E-01
7,0552E+02	1,0631E-03	5,4065E-02	2,2379E-01
7,1334E+02	1,0512E-03	5,2966E-02	2,1921E-01

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
7,2125E+02	1,0395E-03	5,1890E-02	2,1471E-01
7,2925E+02	1,0279E-03	5,0835E-02	2,1031E-01
7,3733E+02	1,0164E-03	4,9802E-02	2,0600E-01
7,4551E+02	1,0051E-03	4,8790E-02	2,0178E-01
7,5377E+02	9,9385E-04	4,7798E-02	1,9764E-01
7,6213E+02	9,8276E-04	4,6826E-02	1,9359E-01
7,7058E+02	9,7180E-04	4,5875E-02	1,8962E-01
7,7913E+02	9,6224E-04	4,4921E-02	1,8565E-01
7,8777E+02	9,5437E-04	4,3961E-02	1,8165E-01
7,9650E+02	9,4656E-04	4,3022E-02	1,7774E-01
8,0533E+02	9,3882E-04	4,2102E-02	1,7391E-01
8,1426E+02	9,3114E-04	4,1202E-02	1,7016E-01
8,2329E+02	9,2353E-04	4,0322E-02	1,6650E-01
8,3242E+02	9,1597E-04	3,9460E-02	1,6291E-01
8,4165E+02	9,0848E-04	3,8617E-02	1,5940E-01
8,5098E+02	9,0105E-04	3,7792E-02	1,5597E-01
8,6041E+02	8,9368E-04	3,6984E-02	1,5261E-01
8,6996E+02	8,8573E-04	3,6196E-02	1,4933E-01
8,7960E+02	8,7665E-04	3,5430E-02	1,4614E-01
8,8935E+02	8,6766E-04	3,4680E-02	1,4302E-01
8,9922E+02	8,5876E-04	3,3946E-02	1,3997E-01
9,0919E+02	8,4995E-04	3,3227E-02	1,3698E-01
9,1927E+02	8,4124E-04	3,2524E-02	1,3405E-01
9,2946E+02	8,3261E-04	3,1835E-02	1,3119E-01
9,3976E+02	8,2407E-04	3,1161E-02	1,2838E-01
9,5018E+02	8,1562E-04	3,0502E-02	1,2564E-01
9,6072E+02	8,0725E-04	2,9856E-02	1,2296E-01
9,7137E+02	7,9893E-04	2,9214E-02	1,2029E-01
9,8214E+02	7,9057E-04	2,8558E-02	1,1756E-01
9,9303E+02	7,8230E-04	2,7916E-02	1,1489E-01
1,0040E+03	7,7411E-04	2,7288E-02	1,1228E-01
1,0152E+03	7,6601E-04	2,6674E-02	1,0973E-01
1,0264E+03	7,5799E-04	2,6075E-02	1,0724E-01
1,0378E+03	7,5006E-04	2,5489E-02	1,0480E-01
1,0493E+03	7,4221E-04	2,4915E-02	1,0243E-01
1,0610E+03	7,3444E-04	2,4355E-02	1,0010E-01
1,0727E+03	7,2675E-04	2,3808E-02	9,7826E-02
1,0846E+03	7,1913E-04	2,3273E-02	9,5609E-02
1,0966E+03	7,1147E-04	2,2757E-02	9,3461E-02
1,1088E+03	7,0389E-04	2,2251E-02	9,1362E-02
1,1211E+03	6,9640E-04	2,1758E-02	8,9311E-02
1,1335E+03	6,8898E-04	2,1274E-02	8,7305E-02
1,1461E+03	6,8164E-04	2,0802E-02	8,5344E-02
1,1588E+03	6,7439E-04	2,0340E-02	8,3428E-02
1,1716E+03	6,6720E-04	1,9889E-02	8,1554E-02
1,1846E+03	6,6010E-04	1,9447E-02	7,9722E-02

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,1978E+03	6,5307E-04	1,9016E-02	7,7932E-02
1,2111E+03	6,4475E-04	1,8592E-02	7,6173E-02
1,2245E+03	6,0525E-04	1,8143E-02	7,4260E-02
1,2381E+03	5,6818E-04	1,7706E-02	7,2394E-02
1,2518E+03	5,3338E-04	1,7279E-02	7,0575E-02
1,2657E+03	5,0071E-04	1,6862E-02	6,8802E-02
1,2797E+03	4,7004E-04	1,6455E-02	6,7074E-02
1,2939E+03	4,4125E-04	1,6058E-02	6,5389E-02
1,3082E+03	4,1422E-04	1,5671E-02	6,3746E-02
1,3227E+03	3,8885E-04	1,5292E-02	6,2144E-02
1,3374E+03	3,6503E-04	1,4924E-02	6,0583E-02
1,3522E+03	3,4267E-04	1,4564E-02	5,9061E-02
1,3672E+03	3,2925E-04	1,4176E-02	5,7439E-02
1,3824E+03	3,1683E-04	1,3796E-02	5,5853E-02
1,3977E+03	3,0488E-04	1,3427E-02	5,4311E-02
1,4132E+03	2,9338E-04	1,3067E-02	5,2811E-02
1,4289E+03	2,8231E-04	1,2717E-02	5,1353E-02
1,4447E+03	2,7167E-04	1,2377E-02	4,9935E-02
1,4607E+03	2,6142E-04	1,2045E-02	4,8556E-02
1,4769E+03	2,5156E-04	1,1723E-02	4,7215E-02
1,4933E+03	2,4207E-04	1,1409E-02	4,5911E-02
1,5099E+03	2,3294E-04	1,1103E-02	4,4644E-02
1,5266E+03	2,2611E-04	1,0685E-02	4,2898E-02
1,5435E+03	2,1985E-04	1,0260E-02	4,1126E-02
1,5607E+03	2,1376E-04	9,8525E-03	3,9427E-02
1,5780E+03	2,0784E-04	9,4609E-03	3,7798E-02
1,5955E+03	2,0208E-04	9,0849E-03	3,6237E-02
1,6132E+03	1,9649E-04	8,7239E-03	3,4740E-02
1,6310E+03	1,9105E-04	8,3771E-03	3,3305E-02
1,6491E+03	1,8576E-04	8,0442E-03	3,1930E-02
1,6674E+03	1,8061E-04	7,7245E-03	3,0611E-02
1,6859E+03	1,7561E-04	7,4175E-03	2,9346E-02
1,7046E+03	1,7104E-04	7,2577E-03	2,8695E-02
1,6596E+03	1,6669E-04	7,1489E-03	2,8257E-02
1,7426E+03	1,6244E-04	7,0418E-03	2,7825E-02
1,7619E+03	1,5831E-04	6,9363E-03	2,7400E-02
1,7815E+03	1,5428E-04	6,8324E-03	2,6982E-02
1,8012E+03	1,5035E-04	6,7300E-03	2,6570E-02
1,8212E+03	1,4652E-04	6,6292E-03	2,6164E-02
1,8414E+03	1,4280E-04	6,5299E-03	2,5764E-02
1,8618E+03	1,3916E-04	6,4320E-03	2,5370E-02
1,8824E+03	1,3562E-04	6,3357E-03	2,4983E-02
1,9033E+03	1,3214E-04	6,2397E-03	2,4598E-02
1,9244E+03	1,2875E-04	6,1445E-03	2,4216E-02
1,9457E+03	1,2544E-04	6,0508E-03	2,3840E-02
1,9673E+03	1,2221E-04	5,9586E-03	2,3471E-02

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,9891E+03	1,1907E-04	5,8677E-03	2,3107E-02
2,0112E+03	1,1601E-04	5,7783E-03	2,2748E-02
2,0335E+03	1,1302E-04	5,6902E-03	2,2395E-02
2,0560E+03	1,1012E-04	5,6034E-03	2,2048E-02
2,0788E+03	1,0729E-04	5,5180E-03	2,1706E-02
2,1019E+03	1,0453E-04	5,4338E-03	2,1369E-02
2,1252E+03	1,0193E-04	5,3498E-03	2,1034E-02
2,1488E+03	9,9463E-05	5,2661E-03	2,0700E-02
2,1726E+03	9,7058E-05	5,1836E-03	2,0372E-02
2,1967E+03	9,4713E-05	5,1024E-03	2,0048E-02
2,2210E+03	9,2423E-05	5,0226E-03	1,9730E-02
2,2457E+03	9,0189E-05	4,9439E-03	1,9417E-02
2,2706E+03	8,8009E-05	4,8665E-03	1,9109E-02
2,2957E+03	8,5882E-05	4,7903E-03	1,8806E-02
2,3212E+03	8,3806E-05	4,7153E-03	1,8507E-02
2,3469E+03	8,1781E-05	4,6415E-03	1,8214E-02
2,3729E+03	7,9815E-05	4,5676E-03	1,7920E-02
2,3993E+03	7,7910E-05	4,4934E-03	1,7625E-02
2,4259E+03	7,6051E-05	4,4204E-03	1,7335E-02
2,4528E+03	7,4236E-05	4,3485E-03	1,7050E-02
2,4799E+03	7,2465E-05	4,2779E-03	1,6770E-02
2,5074E+03	7,0735E-05	4,2083E-03	1,6494E-02
2,5352E+03	6,9047E-05	4,1399E-03	1,6222E-02
2,5634E+03	6,7399E-05	4,0727E-03	1,5955E-02
2,5918E+03	6,5791E-05	4,0065E-03	1,5693E-02
2,6205E+03	6,4221E-05	3,9413E-03	1,5435E-02
2,6496E+03	6,2683E-05	3,8766E-03	1,5178E-02
2,6790E+03	6,1169E-05	3,8117E-03	1,4922E-02
2,7087E+03	5,9693E-05	3,7479E-03	1,4669E-02
2,7387E+03	5,8252E-05	3,6851E-03	1,4421E-02
2,7691E+03	5,6846E-05	3,6234E-03	1,4177E-02
2,7998E+03	5,5474E-05	3,5628E-03	1,3937E-02
2,8308E+03	5,4135E-05	3,5031E-03	1,3701E-02
2,8622E+03	5,2828E-05	3,4444E-03	1,3469E-02
2,8939E+03	5,1553E-05	3,3868E-03	1,3241E-02
2,9260E+03	5,0308E-05	3,3301E-03	1,3017E-02
2,9585E+03	4,9086E-05	3,2736E-03	1,2795E-02
2,9913E+03	4,7866E-05	3,2161E-03	1,2568E-02
3,0244E+03	4,6677E-05	3,1596E-03	1,2345E-02
3,0580E+03	4,5517E-05	3,1040E-03	1,2126E-02
3,0919E+03	4,4387E-05	3,0495E-03	1,1912E-02
3,1261E+03	4,3284E-05	2,9959E-03	1,1701E-02
3,1608E+03	4,2209E-05	2,9432E-03	1,1493E-02
3,1959E+03	4,1160E-05	2,8915E-03	1,1290E-02
3,2313E+03	4,0137E-05	2,8407E-03	1,1090E-02
3,2671E+03	3,9140E-05	2,7908E-03	1,0893E-02

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
3,3033E+03	3,8170E-05	2,7415E-03	1,0699E-02
3,3400E+03	3,7238E-05	2,6919E-03	1,0504E-02
3,3770E+03	3,6329E-05	2,6431E-03	1,0313E-02
3,4144E+03	3,5442E-05	2,5953E-03	1,0125E-02
3,4523E+03	3,4576E-05	2,5483E-03	9,9405E-03
3,4906E+03	3,3732E-05	2,5022E-03	9,7594E-03
3,5293E+03	3,2908E-05	2,4569E-03	9,5816E-03
3,5684E+03	3,2105E-05	2,4124E-03	9,4070E-03
3,6080E+03	3,1321E-05	2,3687E-03	9,2356E-03
3,6480E+03	3,0556E-05	2,3258E-03	9,0673E-03
3,6884E+03	2,9810E-05	2,2837E-03	8,9020E-03
3,7293E+03	2,9092E-05	2,2410E-03	8,7346E-03
3,7707E+03	2,8392E-05	2,1991E-03	8,5705E-03
3,8125E+03	2,7708E-05	2,1581E-03	8,4094E-03
3,8548E+03	2,7041E-05	2,1177E-03	8,2513E-03
3,8975E+03	2,6390E-05	2,0782E-03	8,0962E-03
3,9407E+03	2,5755E-05	2,0393E-03	7,9440E-03
3,9844E+03	2,5135E-05	2,0012E-03	7,7947E-03
4,0286E+03	2,4530E-05	1,9638E-03	7,6482E-03
4,0733E+03	2,3939E-05	1,9272E-03	7,5045E-03
4,1184E+03	2,3363E-05	1,8911E-03	7,3634E-03
4,1641E+03	2,2793E-05	1,8541E-03	7,2183E-03
4,2103E+03	2,2236E-05	1,8176E-03	7,0756E-03
4,2569E+03	2,1693E-05	1,7819E-03	6,9356E-03
4,3041E+03	2,1164E-05	1,7468E-03	6,7985E-03
4,3519E+03	2,0647E-05	1,7124E-03	6,6640E-03
4,4001E+03	2,0143E-05	1,6788E-03	6,5322E-03
4,4489E+03	1,9651E-05	1,6457E-03	6,4030E-03
4,4982E+03	1,9172E-05	1,6134E-03	6,2764E-03
4,5481E+03	1,8704E-05	1,5816E-03	6,1523E-03
4,5985E+03	1,8247E-05	1,5505E-03	6,0306E-03
4,6495E+03	1,7794E-05	1,5181E-03	5,9040E-03
4,7011E+03	1,7351E-05	1,4861E-03	5,7786E-03
4,7532E+03	1,6919E-05	1,4547E-03	5,6559E-03
4,8059E+03	1,6498E-05	1,4239E-03	5,5358E-03
4,8592E+03	1,6087E-05	1,3938E-03	5,4182E-03
4,9131E+03	1,5686E-05	1,3644E-03	5,3031E-03
4,9676E+03	1,5296E-05	1,3356E-03	5,1904E-03
5,0226E+03	1,4915E-05	1,3074E-03	5,0802E-03
5,0783E+03	1,4544E-05	1,2797E-03	4,9723E-03
5,1346E+03	1,4182E-05	1,2527E-03	4,8667E-03
5,1916E+03	1,3828E-05	1,2250E-03	4,7585E-03
5,2491E+03	1,3483E-05	1,1975E-03	4,6509E-03
5,3073E+03	1,3146E-05	1,1706E-03	4,5458E-03
5,3662E+03	1,2818E-05	1,1443E-03	4,4430E-03
5,4257E+03	1,2498E-05	1,1186E-03	4,3426E-03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
5,4858E+03	1,2186E-05	1,0935E-03	4,2444E-03
5,5467E+03	1,1882E-05	1,0690E-03	4,1485E-03
5,6082E+03	1,1585E-05	1,0450E-03	4,0547E-03
5,6703E+03	1,1296E-05	1,0215E-03	3,9630E-03
5,7332E+03	1,1014E-05	9,9856E-04	3,8735E-03
5,7968E+03	1,0739E-05	9,7623E-04	3,7864E-03
5,8611E+03	1,0470E-05	9,5445E-04	3,7015E-03
5,9261E+03	1,0209E-05	9,3317E-04	3,6185E-03
5,9918E+03	9,9536E-06	9,1235E-04	3,5374E-03
6,0582E+03	9,7049E-06	8,9200E-04	3,4581E-03
6,1254E+03	9,4623E-06	8,7211E-04	3,3806E-03
6,1933E+03	9,2259E-06	8,5266E-04	3,3048E-03
6,2620E+03	8,9953E-06	8,3364E-04	3,2308E-03
6,3314E+03	8,7705E-06	8,1505E-04	3,1583E-03
6,4016E+03	8,5514E-06	7,9687E-04	3,0876E-03
6,4726E+03	8,3357E-06	7,7831E-04	3,0152E-03
6,5443E+03	8,1236E-06	7,5948E-04	2,9418E-03
6,6169E+03	7,9170E-06	7,4111E-04	2,8701E-03
6,6903E+03	7,7156E-06	7,2318E-04	2,8002E-03
6,7644E+03	7,5193E-06	7,0568E-04	2,7321E-03
6,8394E+03	7,3280E-06	6,8861E-04	2,6655E-03
6,9153E+03	7,1416E-06	6,7196E-04	2,6006E-03
6,9920E+03	6,9600E-06	6,5570E-04	2,5373E-03
7,0695E+03	6,7829E-06	6,3984E-04	2,4755E-03
7,1479E+03	6,6104E-06	6,2436E-04	2,4152E-03
7,2271E+03	6,4375E-06	6,0798E-04	2,3513E-03
7,3073E+03	6,2629E-06	5,9033E-04	2,2823E-03
7,3883E+03	6,0930E-06	5,7320E-04	2,2154E-03
7,4702E+03	5,9277E-06	5,5656E-04	2,1504E-03
7,5530E+03	5,7669E-06	5,4041E-04	2,0874E-03
7,6368E+03	5,6105E-06	5,2472E-04	2,0262E-03
7,7215E+03	5,4583E-06	5,0949E-04	1,9668E-03
7,8071E+03	5,3103E-06	4,9470E-04	1,9091E-03
7,8936E+03	5,1662E-06	4,8035E-04	1,8531E-03
7,9812E+03	5,0261E-06	4,6640E-04	1,7988E-03
8,0696E+03	4,8924E-06	4,5376E-04	1,7496E-03
8,1591E+03	4,7675E-06	4,4327E-04	1,7091E-03
8,2496E+03	4,6458E-06	4,3303E-04	1,6695E-03
8,3411E+03	4,5273E-06	4,2302E-04	1,6308E-03
8,4335E+03	4,4117E-06	4,1325E-04	1,5931E-03
8,5271E+03	4,2991E-06	4,0370E-04	1,5562E-03
8,6216E+03	4,1894E-06	3,9437E-04	1,5201E-03
8,7172E+03	4,0825E-06	3,8526E-04	1,4849E-03
8,8139E+03	3,9783E-06	3,7636E-04	1,4505E-03
8,9116E+03	3,8768E-06	3,6766E-04	1,4170E-03
9,0104E+03	3,7766E-06	3,5889E-04	1,3830E-03

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
9,1103E+03	3,6747E-06	3,4937E-04	1,3462E-03
9,2113E+03	3,5756E-06	3,4011E-04	1,3104E-03
9,3134E+03	3,4791E-06	3,3109E-04	1,2755E-03
9,4167E+03	3,3853E-06	3,2231E-04	1,2416E-03
9,5211E+03	3,2940E-06	3,1376E-04	1,2086E-03
9,6267E+03	3,2051E-06	3,0544E-04	1,1764E-03
9,7334E+03	3,1187E-06	2,9734E-04	1,1451E-03
9,8414E+03	3,0346E-06	2,8946E-04	1,1146E-03
9,9505E+03	2,9527E-06	2,8178E-04	1,0850E-03
1,0061E+04	2,8732E-06	2,7431E-04	1,0561E-03
1,0172E+04	2,7964E-06	2,6706E-04	1,0281E-03
1,0285E+04	2,7218E-06	2,5999E-04	1,0008E-03
1,0399E+04	2,6491E-06	2,5312E-04	9,7421E-04
1,0514E+04	2,5783E-06	2,4642E-04	9,4835E-04
1,0631E+04	2,5095E-06	2,3991E-04	9,2318E-04
1,0749E+04	2,4425E-06	2,3356E-04	8,9868E-04
1,0868E+04	2,3772E-06	2,2739E-04	8,7482E-04
1,0989E+04	2,3138E-06	2,2137E-04	8,5160E-04
1,1110E+04	2,2520E-06	2,1552E-04	8,2899E-04
1,1234E+04	2,1918E-06	2,0981E-04	8,0695E-04
1,1358E+04	2,1303E-06	2,0385E-04	7,8391E-04
1,1484E+04	2,0706E-06	1,9806E-04	7,6151E-04
1,1612E+04	2,0126E-06	1,9244E-04	7,3976E-04
1,1740E+04	1,9562E-06	1,8697E-04	7,1863E-04
1,1870E+04	1,9013E-06	1,8166E-04	6,9811E-04
1,2002E+04	1,8481E-06	1,7650E-04	6,7817E-04
1,2135E+04	1,7963E-06	1,7149E-04	6,5880E-04
1,2270E+04	1,7459E-06	1,6662E-04	6,3998E-04
1,2406E+04	1,6970E-06	1,6188E-04	6,2170E-04
1,2543E+04	1,6494E-06	1,5728E-04	6,0394E-04
1,2682E+04	1,6012E-06	1,5247E-04	5,8536E-04
1,2823E+04	1,5542E-06	1,4778E-04	5,6723E-04
1,2965E+04	1,5086E-06	1,4322E-04	5,4967E-04
1,3109E+04	1,4644E-06	1,3881E-04	5,3265E-04
1,3254E+04	1,4214E-06	1,3454E-04	5,1616E-04
1,3401E+04	1,3797E-06	1,3040E-04	5,0017E-04
1,3550E+04	1,3393E-06	1,2638E-04	4,8469E-04
1,3700E+04	1,3000E-06	1,2249E-04	4,6968E-04
1,3852E+04	1,2619E-06	1,1872E-04	4,5513E-04
1,4006E+04	1,2248E-06	1,1506E-04	4,4104E-04
1,4161E+04	1,1875E-06	1,1112E-04	4,2583E-04
1,4318E+04	1,1510E-06	1,0722E-04	4,1080E-04
1,4477E+04	1,1157E-06	1,0347E-04	3,9631E-04
1,4637E+04	1,0814E-06	9,9843E-05	3,8233E-04
1,4799E+04	1,0481E-06	9,6345E-05	3,6884E-04
1,4963E+04	1,0159E-06	9,2970E-05	3,5583E-04

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
1,5129E+04	9,8472E-07	8,9713E-05	3,4328E-04
1,5297E+04	9,5446E-07	8,6570E-05	3,3117E-04
1,5467E+04	9,2513E-07	8,3537E-05	3,1948E-04
1,5638E+04	8,9670E-07	8,0610E-05	3,0821E-04
1,5812E+04	8,6952E-07	7,7999E-05	2,9818E-04
1,5987E+04	8,4330E-07	7,5552E-05	2,8880E-04
1,6164E+04	8,1787E-07	7,3183E-05	2,7972E-04
1,6343E+04	7,9321E-07	7,0888E-05	2,7092E-04
1,6525E+04	7,6929E-07	6,8665E-05	2,6240E-04
1,6708E+04	7,4610E-07	6,6511E-05	2,5414E-04
1,6893E+04	7,2360E-07	6,4425E-05	2,4615E-04
1,7080E+04	7,0178E-07	6,2405E-05	2,3840E-04
1,7270E+04	6,8062E-07	6,0448E-05	2,3090E-04
1,7461E+04	6,6010E-07	5,8552E-05	2,2364E-04
1,7655E+04	6,3946E-07	5,6784E-05	2,1687E-04
1,7851E+04	6,1901E-07	5,5110E-05	2,1048E-04
1,8049E+04	5,9923E-07	5,3485E-05	2,0427E-04
1,8249E+04	5,8007E-07	5,1909E-05	1,9824E-04
1,8451E+04	5,6153E-07	5,0378E-05	1,9239E-04
1,8656E+04	5,4358E-07	4,8893E-05	1,8672E-04
1,8863E+04	5,2620E-07	4,7452E-05	1,8121E-04
1,9072E+04	5,0938E-07	4,6053E-05	1,7586E-04
1,9283E+04	4,9310E-07	4,4696E-05	1,7067E-04
1,9497E+04	4,7733E-07	4,3378E-05	1,6564E-04
1,9713E+04	4,6067E-07	4,1990E-05	1,6033E-04
1,9932E+04	4,4332E-07	4,0547E-05	1,5481E-04
2,0153E+04	4,2662E-07	3,9153E-05	1,4948E-04
2,0376E+04	4,1055E-07	3,7807E-05	1,4434E-04
2,0602E+04	3,9508E-07	3,6508E-05	1,3937E-04
2,0831E+04	3,8020E-07	3,5253E-05	1,3457E-04
2,1061E+04	3,6588E-07	3,4041E-05	1,2994E-04
2,1295E+04	3,5209E-07	3,2871E-05	1,2546E-04
2,1531E+04	3,3883E-07	3,1741E-05	1,2114E-04
2,1770E+04	3,2607E-07	3,0650E-05	1,1697E-04
2,2011E+04	3,1246E-07	2,9509E-05	1,1261E-04
2,2255E+04	2,9762E-07	2,8292E-05	1,0795E-04
2,2502E+04	2,8350E-07	2,7125E-05	1,0349E-04
2,2752E+04	2,7004E-07	2,6006E-05	9,9210E-05
2,3004E+04	2,5722E-07	2,4933E-05	9,5107E-05
2,3259E+04	2,4501E-07	2,3905E-05	9,1175E-05
2,3517E+04	2,3338E-07	2,2919E-05	8,7405E-05
2,3778E+04	2,2230E-07	2,1973E-05	8,3790E-05
2,4041E+04	2,1175E-07	2,1067E-05	8,0326E-05
2,4308E+04	2,0170E-07	2,0198E-05	7,7004E-05
2,4577E+04	1,9076E-07	1,9269E-05	7,3457E-05
2,4850E+04	1,7762E-07	1,8186E-05	6,9318E-05

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
2,5125E+04	1,6539E-07	1,7164E-05	6,5413E-05
2,5404E+04	1,5400E-07	1,6199E-05	6,1728E-05
2,5686E+04	1,4339E-07	1,5288E-05	5,8250E-05
2,5970E+04	1,3351E-07	1,4428E-05	5,4968E-05
2,6258E+04	1,2432E-07	1,3617E-05	5,1871E-05
2,6549E+04	1,1576E-07	1,2852E-05	4,8949E-05
2,6844E+04	1,0778E-07	1,2129E-05	4,6191E-05
2,7141E+04	1,0036E-07	1,1447E-05	4,3589E-05
2,7442E+04	8,8766E-08	1,0153E-05	3,8657E-05
2,7747E+04	6,4873E-08	7,1500E-06	2,7223E-05
2,8054E+04	4,7411E-08	5,0352E-06	1,9171E-05
2,8365E+04	3,4650E-08	3,5459E-06	1,3501E-05
2,8680E+04	2,5323E-08	2,4972E-06	9,5075E-06
2,8998E+04	1,8507E-08	1,7586E-06	6,6954E-06
2,9319E+04	1,3525E-08	1,2384E-06	4,7150E-06
2,9645E+04	9,8848E-09	8,7214E-07	3,3204E-06
2,9973E+04	7,2241E-09	6,1419E-07	2,3383E-06
3,0306E+04	5,2796E-09	4,3253E-07	1,6467E-06
3,0642E+04	3,8826E-09	3,0596E-07	1,1645E-06
3,0981E+04	3,0008E-09	2,2430E-07	8,5180E-07
3,1325E+04	2,3192E-09	1,6443E-07	6,2306E-07
3,1672E+04	1,7925E-09	1,2054E-07	4,5574E-07
3,2023E+04	1,3854E-09	8,8368E-08	3,3335E-07
3,2378E+04	1,0707E-09	6,4782E-08	2,4383E-07
3,2737E+04	8,2753E-10	4,7491E-08	1,7835E-07
3,3100E+04	6,3958E-10	3,4815E-08	1,3046E-07
3,3467E+04	4,9432E-10	2,5523E-08	9,5424E-08
3,3839E+04	3,8205E-10	1,8710E-08	6,9798E-08
3,4214E+04	2,9587E-10	1,3747E-08	5,1169E-08
3,4593E+04	2,7875E-10	1,2570E-08	4,6736E-08
3,4977E+04	2,6262E-10	1,1494E-08	4,2687E-08
3,5364E+04	2,4742E-10	1,0510E-08	3,8989E-08
3,5757E+04	2,3310E-10	9,6100E-09	3,5611E-08
3,6153E+04	2,1961E-10	8,7872E-09	3,2526E-08
3,6554E+04	2,0691E-10	8,0349E-09	2,9708E-08
3,6959E+04	1,9493E-10	7,3470E-09	2,7135E-08
3,7369E+04	1,8365E-10	6,7180E-09	2,4784E-08
3,7783E+04	1,7303E-10	6,1428E-09	2,2637E-08
3,8202E+04	1,6301E-10	5,6169E-09	2,0676E-08
3,8626E+04	1,5654E-10	5,2889E-09	1,9460E-08
3,9054E+04	1,5060E-10	4,9946E-09	1,8370E-08
3,9487E+04	1,4489E-10	4,7167E-09	1,7342E-08
3,9925E+04	1,3939E-10	4,4543E-09	1,6371E-08
4,0368E+04	1,3411E-10	4,2065E-09	1,5455E-08
4,0815E+04	1,2902E-10	3,9724E-09	1,4590E-08
4,1268E+04	1,2413E-10	3,7514E-09	1,3773E-08

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
4,1725E+04	1,1942E-10	3,5427E-09	1,3002E-08
4,2188E+04	1,1490E-10	3,3456E-09	1,2274E-08
4,2656E+04	1,1054E-10	3,1595E-09	1,1587E-08
4,3129E+04	1,0631E-10	3,0169E-09	1,1060E-08
4,3607E+04	1,0224E-10	2,8883E-09	1,0584E-08
4,4091E+04	9,8323E-11	2,7651E-09	1,0130E-08
4,4579E+04	9,4556E-11	2,6472E-09	9,6942E-09
4,5074E+04	9,0934E-11	2,5344E-09	9,2776E-09
4,5573E+04	8,7450E-11	2,4264E-09	8,8789E-09
4,6079E+04	8,4100E-11	2,3229E-09	8,4973E-09
4,6590E+04	8,0878E-11	2,2239E-09	8,1321E-09
4,7106E+04	7,7780E-11	2,1291E-09	7,7826E-09
4,7629E+04	7,4800E-11	2,0383E-09	7,4481E-09
4,8157E+04	7,1992E-11	1,9602E-09	7,1609E-09
4,8691E+04	6,9312E-11	1,8886E-09	6,8978E-09
4,9231E+04	6,6732E-11	1,8196E-09	6,6444E-09
4,9776E+04	6,4248E-11	1,7532E-09	6,4003E-09
5,0328E+04	6,1857E-11	1,6891E-09	6,1652E-09
5,0886E+04	5,9554E-11	1,6274E-09	5,9387E-09
5,1451E+04	5,7337E-11	1,5680E-09	5,7206E-09
5,2021E+04	5,5203E-11	1,5107E-09	5,5104E-09
5,2598E+04	5,3148E-11	1,4555E-09	5,3080E-09
5,3181E+04	5,1170E-11	1,4024E-09	5,1130E-09
5,3771E+04	4,9108E-11	1,3430E-09	4,8956E-09
5,4367E+04	4,7031E-11	1,2811E-09	4,6692E-09
5,4970E+04	4,5042E-11	1,2220E-09	4,4532E-09
5,5579E+04	4,3137E-11	1,1657E-09	4,2472E-09
5,6195E+04	4,1312E-11	1,1120E-09	4,0508E-09
5,6819E+04	3,9565E-11	1,0607E-09	3,8634E-09
5,7449E+04	3,7892E-11	1,0118E-09	3,6847E-09
5,8086E+04	3,6289E-11	9,6517E-10	3,5143E-09
5,8730E+04	3,4754E-11	9,2067E-10	3,3517E-09
5,9381E+04	3,3284E-11	8,7823E-10	3,1967E-09
6,0039E+04	3,1736E-11	8,3148E-10	3,0262E-09
6,0705E+04	3,0129E-11	7,8144E-10	2,8438E-09
6,1378E+04	2,8603E-11	7,3441E-10	2,6725E-09
6,2058E+04	2,7155E-11	6,9021E-10	2,5115E-09
6,2747E+04	2,5780E-11	6,4868E-10	2,3601E-09
6,3442E+04	2,4475E-11	6,0964E-10	2,2179E-09
6,4146E+04	2,3235E-11	5,7295E-10	2,0843E-09
6,4857E+04	2,2059E-11	5,3847E-10	1,9587E-09
6,5576E+04	2,0942E-11	5,0606E-10	1,8407E-09
6,6303E+04	1,9881E-11	4,7561E-10	1,7298E-09
6,7038E+04	1,8843E-11	4,4991E-10	1,6360E-09
6,7782E+04	1,7816E-11	4,2972E-10	1,5618E-09
6,8533E+04	1,6845E-11	4,1044E-10	1,4910E-09

Shielding Thickness 3.7 mm Al			
LET	800 km 98° GCR INTEGRAL FLUX	800 km 98° SOLAR HEAVY IONS INTEGRAL FLUX	GEO (SOLAR IONS GCR) +
[Mev,cm2,g-1]	[cm-2,s-1]	[cm-2,s-1]	[cm-2,s-1]
6,9293E+04	1,5927E-11	3,9202E-10	1,4235E-09
7,0061E+04	1,5059E-11	3,7443E-10	1,3589E-09
7,0838E+04	1,4238E-11	3,5762E-10	1,2973E-09
7,1624E+04	1,3462E-11	3,4158E-10	1,2385E-09
7,2418E+04	1,2728E-11	3,2625E-10	1,1824E-09
7,3221E+04	1,2035E-11	3,1161E-10	1,1288E-09
7,4033E+04	1,1379E-11	2,9762E-10	1,0777E-09
7,4854E+04	1,0697E-11	2,8344E-10	1,0258E-09
7,5684E+04	9,9244E-12	2,6812E-10	9,6972E-10
7,6523E+04	9,2077E-12	2,5362E-10	9,1673E-10
7,7371E+04	8,5427E-12	2,3992E-10	8,6664E-10
7,8229E+04	7,9258E-12	2,2695E-10	8,1928E-10
7,9096E+04	7,3534E-12	2,1468E-10	7,7451E-10
7,9973E+04	6,8223E-12	2,0308E-10	7,3219E-10
8,0860E+04	6,3296E-12	1,9210E-10	6,9218E-10
8,1757E+04	5,8725E-12	1,8172E-10	6,5436E-10
8,2663E+04	5,4484E-12	1,7190E-10	6,1861E-10
8,3580E+04	4,9628E-12	1,6006E-10	5,7561E-10
8,4507E+04	4,2037E-12	1,4005E-10	5,0309E-10
8,5444E+04	3,5607E-12	1,2254E-10	4,3971E-10
8,6391E+04	3,0161E-12	1,0722E-10	3,8432E-10
8,7349E+04	2,5547E-12	9,3809E-11	3,3590E-10
8,8317E+04	2,1640E-12	8,2079E-11	2,9359E-10
8,9297E+04	1,8330E-12	7,1816E-11	2,5660E-10
9,0287E+04	1,5526E-12	6,2836E-11	2,2428E-10
9,1288E+04	1,3151E-12	5,4979E-11	1,9602E-10
9,2300E+04	1,1140E-12	4,8104E-11	1,7133E-10
9,3323E+04	9,3322E-13	4,1080E-11	1,4621E-10
9,4358E+04	7,0874E-13	2,8266E-11	1,0085E-10
9,5404E+04	5,3826E-13	1,9449E-11	6,9565E-11
9,6462E+04	4,0879E-13	1,3383E-11	4,7985E-11
9,7532E+04	3,1046E-13	9,2083E-12	3,3099E-11
9,8613E+04	2,3578E-13	6,3360E-12	2,2831E-11
9,9707E+04	1,7906E-13	4,3597E-12	1,5749E-11
1,0081E+05	1,3599E-13	2,9998E-12	1,0863E-11
1,0193E+05	1,0328E-13	2,0641E-12	7,4932E-12
1,0306E+05	7,8436E-14	1,4203E-12	5,1687E-12
1,0420E+05	5,9569E-14	9,7724E-13	3,5653E-12

Table 6611. Trapped protons integral flux expected in the ISIS LEO reference (800 km, 98°, 10 years), JASON 2 (1330 km, 66°, 10 years), and Lowest LEO (400 km, 33°, 10 years) orbits.

Incident Trapped Protons ENERGY	INTEGRAL FLUX[cm-2.s-1]		
[MeV]	800 km 98° 10 years reference	JASON 2 1330 km 66° 10 years	400 km 33° 10 years
0,1	7,18E+03	7,21E+04	2,06E+01
0,25	3,13E+03	2,83E+04	2,04E+01
0,5	1,35E+03	1,08E+04	2,01E+01
0,75	8,41E+02	6,36E+03	1,98E+01
1	6,27E+02	4,68E+03	1,96E+01
2	3,58E+02	2,79E+03	1,93E+01
3	2,78E+02	2,29E+03	1,91E+01
4	2,32E+02	2,00E+03	1,89E+01
5	2,08E+02	1,83E+03	1,87E+01
6	1,90E+02	1,70E+03	1,85E+01
8	1,68E+02	1,52E+03	1,81E+01
10	1,55E+02	1,39E+03	1,77E+01
12	1,47E+02	1,30E+03	1,75E+01
15	1,37E+02	1,18E+03	1,71E+01
17	1,32E+02	1,13E+03	1,68E+01
20	1,25E+02	1,06E+03	1,64E+01
25	1,18E+02	9,89E+02	1,58E+01
30	1,12E+02	9,25E+02	1,52E+01
35	1,06E+02	8,79E+02	1,46E+01
40	1,01E+02	8,36E+02	1,40E+01
45	9,68E+01	7,95E+02	1,35E+01
50	9,24E+01	7,57E+02	1,29E+01
60	8,39E+01	6,89E+02	1,18E+01
70	7,60E+01	6,24E+02	1,08E+01
80	6,89E+01	5,66E+02	9,80E+00
90	6,23E+01	5,12E+02	8,86E+00
100	5,64E+01	4,64E+02	8,01E+00
125	4,35E+01	3,61E+02	6,06E+00
150	3,38E+01	2,81E+02	4,60E+00
175	2,63E+01	2,19E+02	3,51E+00
200	2,05E+01	1,71E+02	2,68E+00
300	7,78E+00	6,61E+01	0,00E+00

Table 7. Worst case integral proton flux expected in the ISIS LEO reference orbit (800 km, 98°, 10 years).

Incident Flare Protons ENERGY	INTEGRAL FLUX[cm-2.s-1]	
[MeV]	800 km 98° 10 years reference	GEO 35870 km 0° 18 years
1	2,78E+05	1,02E+06
3	1,22E+05	4,34E+05
5	7,46E+04	2,77E+05
7	5,29E+04	2,00E+05
10	3,62E+04	1,37E+05
15	2,17E+04	8,43E+04
20	1,46E+04	5,74E+04
25	1,04E+04	4,14E+04
30	7,76E+03	3,11E+04
35	5,97E+03	2,41E+04
40	4,72E+03	1,91E+04
45	3,79E+03	1,55E+04
50	3,11E+03	1,27E+04
55	2,56E+03	1,06E+04
60	2,16E+03	8,87E+03
70	1,55E+03	6,45E+03
80	1,16E+03	4,83E+03
90	8,74E+02	3,71E+03
100	6,86E+02	2,91E+03
125	3,94E+02	1,75E+03
150	2,40E+02	1,13E+03
175	1,50E+02	7,76E+02
200	9,42E+01	5,55E+02
225	5,74E+01	4,10E+02
250	3,17E+01	3,11E+02
275	1,34E+01	2,39E+02
300	0,00E+00	1,88E+02

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